PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

16

Applicant's or agent's file reference 1320PCT	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No. **PCT/AU99/00659**	International filing date *(day/month/year)* 13 August 1999	Priority Date *(day/month/year)* 13 August 1998

International Patent Classification (IPC) or national classification and IPC

Int. Cl. [7] C07K 16/24 16/28

Applicant

MEDVET SCIENCE PTY LTD et al

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 8 sheet(s).

3. This report contains indications relating to the following items:

I	☒	Basis of the report
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☐	Lack of unity of invention
V	☒	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain documents cited
VII	☐	Certain defects in the international application
VIII	☒	Certain observations on the international application

Date of submission of the demand	Date of completion of the report
23 February 2000	1 August 2000
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **GAVIN THOMPSON** Telephone No. (02) 6283 2240

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU99/00659

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed.

☒ the description, pages **1 to 27** as originally filed,
pages , filed with the demand,
pages , received on with the letter of

☒ the claims, pages **28** as originally filed,
pages , as amended (together with any statement) under Article 19,
pages , filed with the demand,
pages **29 to 32** received on **19 October 1999** with the letter of **19 October 1999**

☒ the drawings, pages **1, 3, 6 to 8, 10 to 14,** as originally filed,
pages filed with the demand, 3
pages **2, 4, 5, 9** received on **14 October 1999** with the letter of **13 October 1999**

☐ the sequence listing part of the description:
pages , as originally filed
pages , filed with the demand
pages , received on with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, was on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages

☐ the claims, Nos.

☐ the drawings, sheets/fig.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	**21 to 27**	**YES**
	Claims	**1 to 20 and 28 to 31**	**NO**
Inventive step (IS)	Claims	**21 to 27**	**YES**
	Claims	**1 to 20 and 28 to 31**	**NO**
Industrial applicability (IA)	Claims	**1 to 31**	**YES**
	Claims		**NO**

2. Citations and explanations (Rule 70.7)

NOVELTY (N) Claims 1 to 9, 11 to 20 and 28 to 31

D1: AU 15366/97 (706462) B (MEDVET SCIENCE PTY. LTD.) 22 August 1997

This citation discloses the preparation of a monoclonal antibody which inhibits the binding of IL-3, GM-SCF and IL-5 with the Beta-c receptor. The inoculating of the animal with a Beta-c receptor with a domain 4(page 7 line 16) begins the antibody preparartion(page 8 line 34 to page 9 line 4).

INVENTIVE STEP (IS) CLAIMS 1 to 9, 11 to 20 and 28 to 31

As above.

NOVELTY (N) Claim 10

D1: citation as above.

D2: BLOOD, Volume 80, No. 9, November 21, (U.S.), Watanabe Y. et al, "Monoclonal Antibody Against the Common Beta Subunit of the Human Interleukin-3 (IL-3), IL-5 and Granulocyte-Macrophage Colony-Stimulating Factor Receptors Shows Upregulation of Beta C by IL-1 and Tumour Necrosis Factor-Alpha", pages 2215-2220.

D3: MOLECULAR AND CELLULAR BIOLOGY, Volume 16, No. 6, June 1996, (U.S.), Stomski F. C. et al, "Human Interleukin-3 (IL-3) Induces Disulfide-Linked IL-3 Receptor alpha- and beta- Chain Heterodimerization. Which is required for Receptor Activation but Not High-Affinity Binding", pages 3035-3046.

These citations disclosed the preparation of monoclonal antibodies that block the binding of IL-3 from the Beta-c receptor. In D2, see the first paragraph of *Cell lines, media and cytokines* and in D3, see lines 9 to 11 of the abstract. As shown by the text above, D1 anticipates this claim also.

INVENTIVE STEP (IS) Claim 10

As above.

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

The incorrectly numbered claim pages 29 to 32 of 19 October 1999 do not completely overlap the lodged claim pages 28 to 31. With the lodged page 28 not replaced, there are two sets of claims 1 to 6.

Claims 10 and 28 are not clear as they do not relate to one invention.

Claim 19 is not clear as the difference between it and claim 18 is non-existent.

Claim 1 is not supported by the description as the cytokine, or portion, of the first step should only have domain 4(page 3 line 19), but in the claim it has at least domain 4 (pages 28,29 lines 5 to 7).

CLAIMS

1. A method of isolating a monoclonal antibody capable of inhibiting any one of IL-3, GM-CSF and IL-5 binding to the common receptor β_c, or a receptor analogous to β_c, said method including the steps of:

immunising an animal with a cytokine receptor or portion of a cytokine containing at least the extracellular domain 4 or analogous domain in the analogous common receptor or part thereof,

isolating antibody producing cells from said animal,

fusing antibody producing cells with a myeloma cell line, and

screening for a cell line that produces the monoclonal antibody of capable of inhibiting any one of IL-3, GM-CSF and IL-5 binding to the common receptor β_c, or a receptor analogous to β_c.

2. A method as in claim 1 wherein the immunisation involves introducing a cDNA clone of a portion of or all of the common receptor including the extracellular domain 4 or analogous domain in the analogous common receptor or part thereof, into a cell and proliferating said cells to form a recombinant cell line, inoculating an animal with said recombinant cell line, isolating antibody producing cells from said animal and fusing the antibody producing cell line with a myeloma cell line to form a hybridoma cell line, screening for a hybridoma cell line that produces an antibody that binds to the recombinant cell line but not to the parent, and then testing for inhibition against all three cytokines.

3. A method as in claim 2 wherein the cell into which the cDNA clone is introduced is mammalian.

4. A method as in claim 3 wherein the mammalian cell line is a COS cell.

5. A method as in claim 2 wherein the cDNA encodes a full or partial portion of domain 4 when it is in a configuration where the F'-G' loop and/or the B'-C' loop is in its native shape.

6. A method as in claim 2 wherein the domain 4 of β_c or equivalent domain in other cytokine receptors is expressed in isolation in a microbial host and used to immunise animals for developing monoclonal antibodies.

7. A method as in claim 2 wherein the analogous receptor is any one of the cytokine superfamily receptors from the group including β_c, LIFR, gp130, IL-2Rβ, IL-4R/IL-13R, IL-2Rγ, IL-3Rα, EPOR, TPOR and OBR.

8. A method as in claim 2 wherein the method is used to isolate a monoclonal antibody that inhibits binding of all of the said receptors to a common receptor.

9. A method as in claim 7 wherein the common receptor is selected from the group of receptors acting for more than one cytokine including but not limited to gp130, LIFR, IL2Rβ/IL2Rα, IL-4R/IL-13R and β_c.

10. A monoclonal antibody, or fragments thereof capable of inhibiting the binding of the cytokines IL-3, GM-CSF and IL-5 to the β_c receptor.

11. A monoclonal antibody as in claim 10 wherein the monoclonal antibody or fragment thereof binds to at least the F'-G' loop of domain 4 of the β_c subunit.

12. A monoclonal antibody as in claim 10 wherein the monoclonal antibody or fragment thereof binds to at least the B'-C' loop of domain 4 of the β_c subunit.

13. A monoclonal antibody as in claim 10 wherein the monoclonal antibody or fragments thereof binds to both the F'-G' as well as the B'C' loop of domain 4 of the β_c.

14 A monoclonal antibody as in claim 10 wherein the monoclonal antibody inhibits β_c receptor dimerisation.

15 A monoclonal antibody as in claim 10 wherein nucleic acid encoding the variable region of the monoclonal antibody is recombined with nucleic acid encoding non-variable regions of human origin in an expression vector.

16. A monoclonal antibody as in claim 10 wherein the inhibition leads to blocking of at least one function of all three cytokines.

17. A monoclonal antibody as in claim 10 wherein the activity leads to inhibition of stimulation of effector cell activation or survival.

18. A monoclonal antibody as in claim 17 wherein the antibody or fragment thereof is used for treatment of asthma and leads to inhibition of IL-5, IL-3 & GM-CSF mediated eosinophil activation.

19. A monoclonal antibody as in claim 17 wherein the antibody or fragment thereof is used for treatment of asthma and leads to inhibition of IL-5, IL-3 & GM-CSF mediated eosinophil survival.

20. A monoclonal antibody as in claim 17 wherein the effector cell is selected from the list including leukaemic cells, endothelial cells, breast cancer cells, prostate cancer cells, small cell lung carcinoma cells, colon cancer cells, macrophages in chronic inflammation, and dendritic cells for immunosuppression.

21. A monoclonal antibody as in claim 17 wherein the monoclonal antibody is the antibody produced by the hybridoma cell line BION-1 (ATCC HB-12525).

22. A hybridoma cell line capable of producing the monoclonal antibody of claim 10.

23. A hybridoma cell line as in claim 22 wherein the hybridoma cell line is BION-1 (ATCC HB-12525).

24 A method of isolating an inhibitor capable of competitively inhibiting the binding of BION-1 or the binding of an agent capable of inhibiting BION-1 binding, to the β_c subunit, the method including the steps of contacting BION-1 or fragment thereof with the β_c subunit or fragment thereof as well as a candidate inhibitory compound,

and measuring the degree of binding.

25 A method as in claim 24 wherein a reporting means is provided to facilitate the detection of binding of BION1 or fragment thereof with β_c subunit or fragment thereof.

26 A method as in claim 24 wherein the inhibitor is a peptide or a nucleotide molecule.

27. An inhibitor isolated by the method of claim 24.

28. A cytokine inhibitor that simultaneously blocks the binding of β_c by IL-3, GM-CSF, and IL-5.

29. An inhibitor of leukaemic cell proliferation wherein the inhibitor inhibits binding of IL-3, GM-CSF and IL-5 with β_c subunit or fragment thereof.

30. An inhibitor as in claim 29 wherein the proliferation of the cell is cytokine dependent.

31. An inhibitor as in claim 29 wherein the inhibitor is BION-1 or an agent capable of inhibiting BION-1 binding with β_c subunit or fragment thereof.

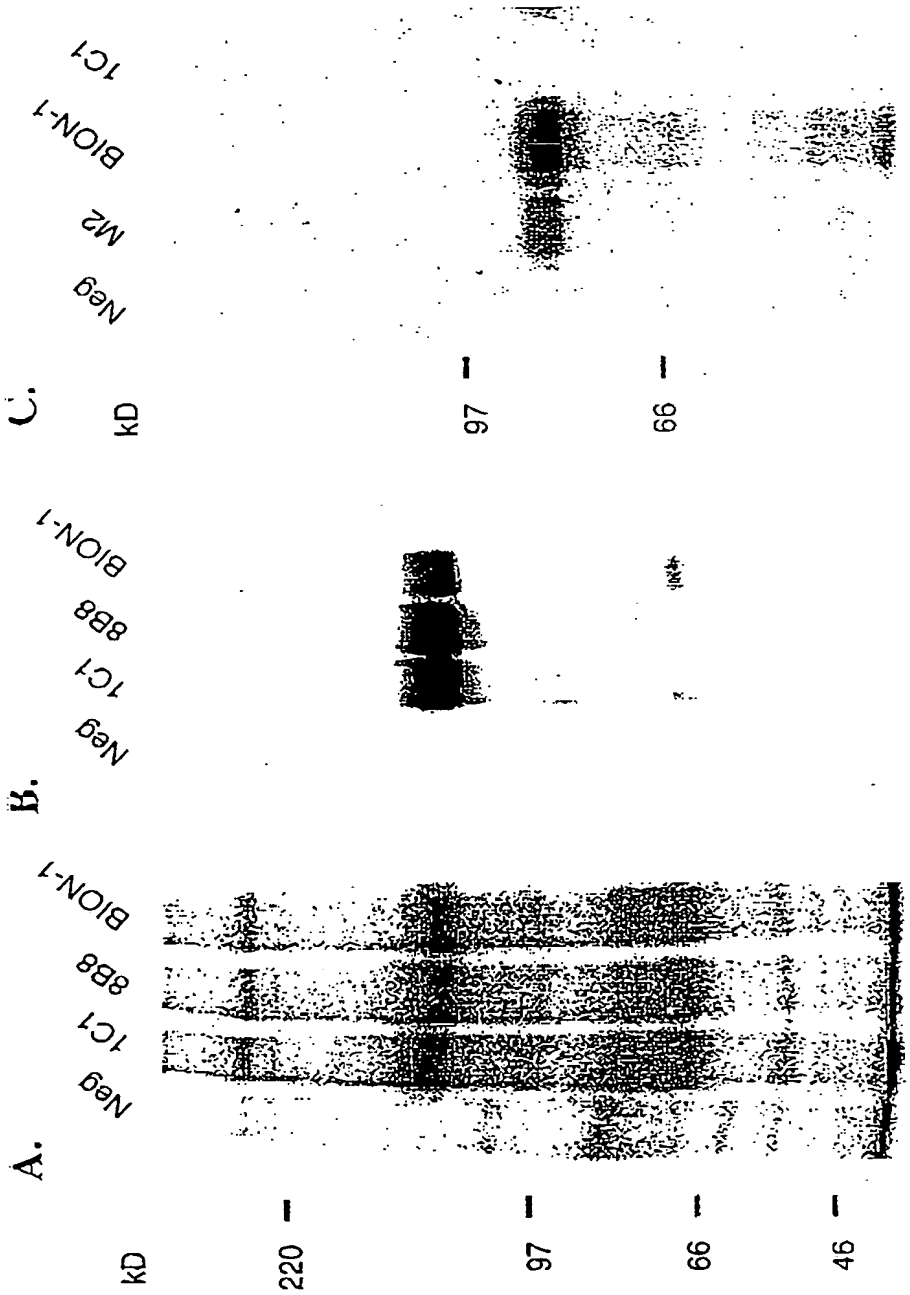

C.
kD
97
66
Neg
M2
BION-1
1C1
B.
Neg
1C1
BBB
BION-1
A.
Neg
1C1
BBB
BION-1
kD
220
97
66
46

FIGURE 2

09/762963

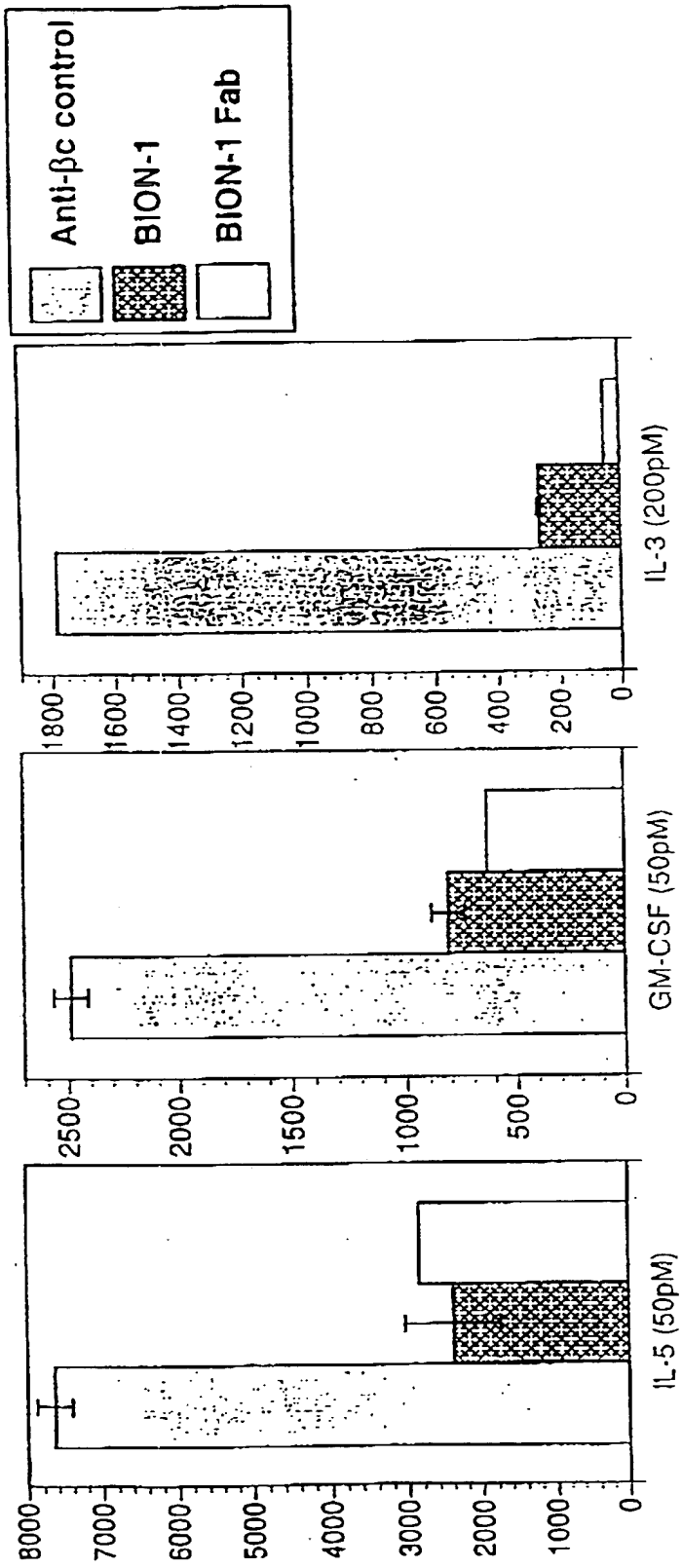


FIGURE 4

09/762963
PCT/AU99/00659
WO 00/09561

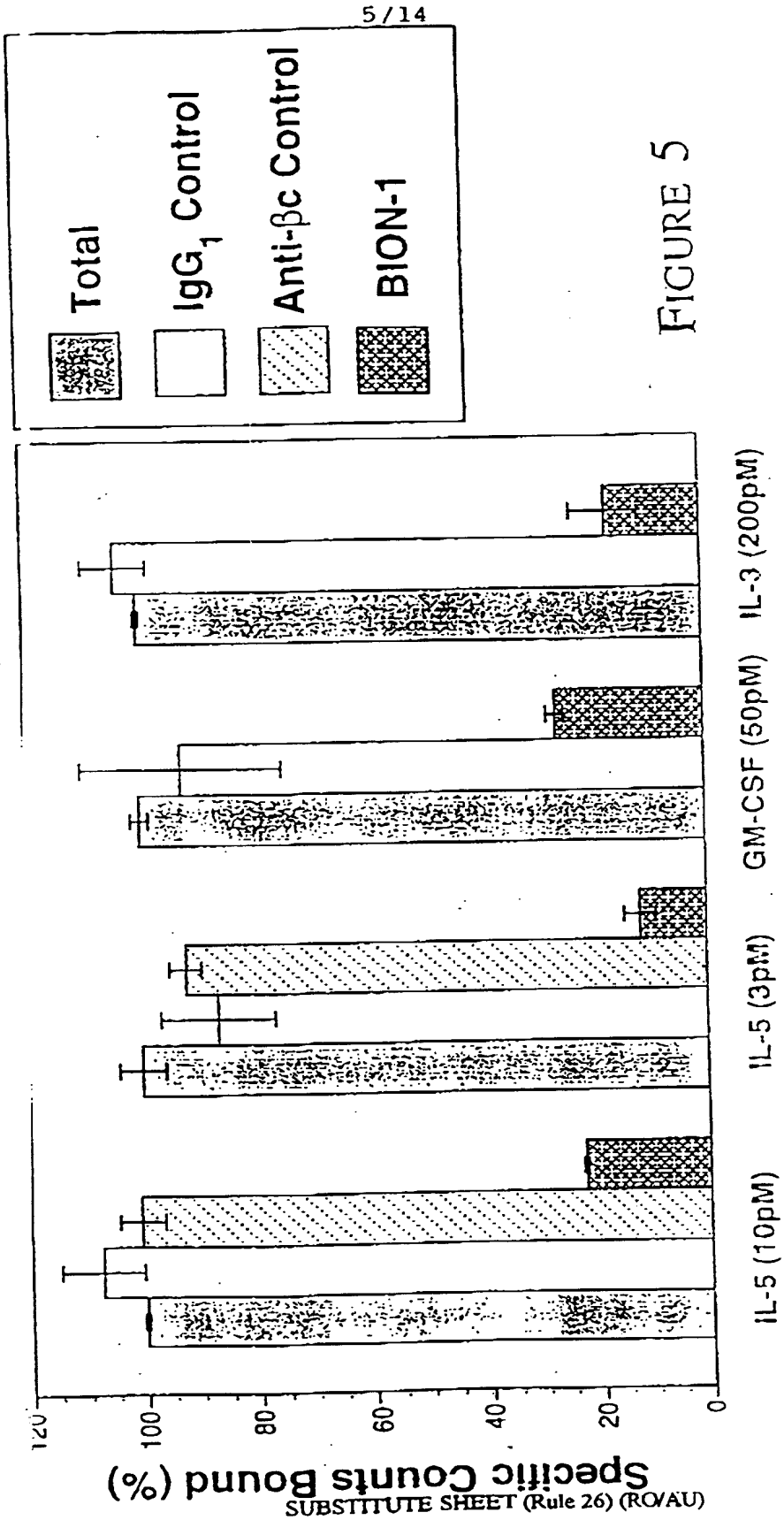
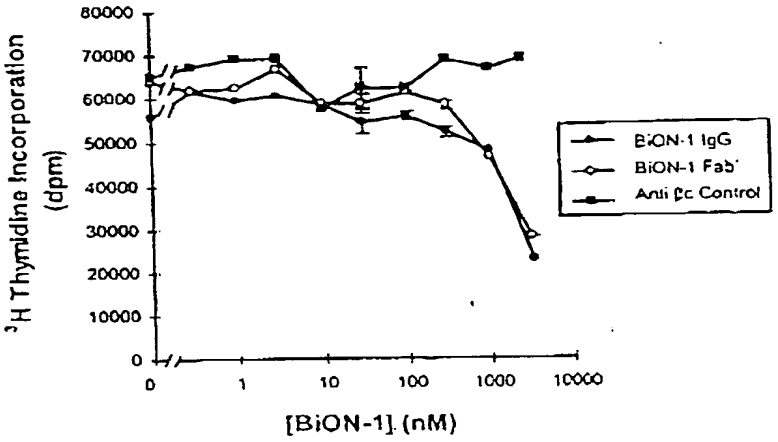


FIGURE 5

BiON-1 + IL5 (0.3ng/ml)



BiON-1 + GM-CSF (0.03ng/ml)

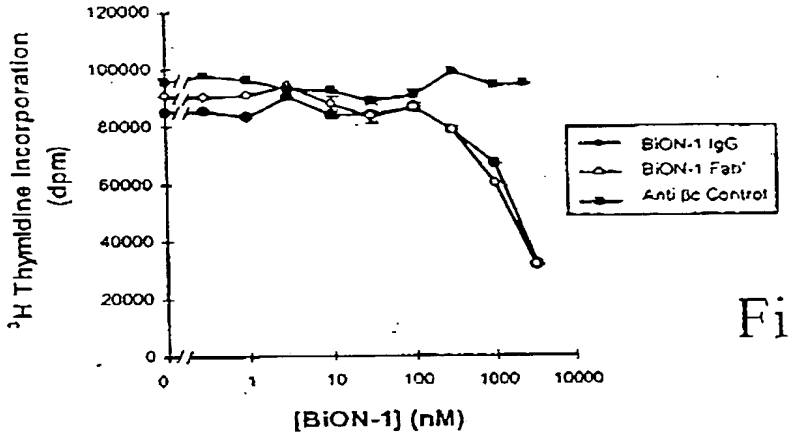
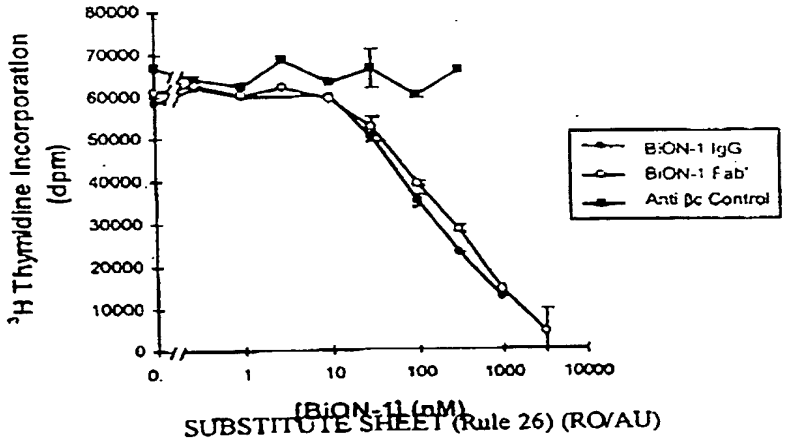


Figure 9

BiON-1 + IL3 (0.3ng/ml)



PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

INFORMATION CONCERNING ELECTED OFFICES NOTIFIED OF THEIR ELECTION

(PCT Rule 61.3)

To:

A.P.T. PATENT & TRADE MARK
ATTORNEYS
G.P.O. Box 772
Adelaide, S.A. 5001
AUSTRALIE

Date of mailing (day/month/year) 16 March 2000 (16.03.00)	
Applicant's or agent's file reference 1320 PCT	**IMPORTANT INFORMATION**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/AU99/00659	13 August 1999 (13.08.99)	13 August 1998 (13.08.98)

Applicant
MEDVET SCIENCE PTY. LTD. et al

1. The applicant is hereby informed that the International Bureau has, according to Article 31(7), notified each of the following Offices of its election:

   AP :GH,GM,KE,LS,MW,SD,SL,SZ,UG,ZW
   EP :AT,BE,CH,CY,DE,DK,ES,FI,FR,GB,GR,IE,IT,LU,MC,NL,PT,SE
   National :AU,BG,BR,CA,CN,CZ,DE,IL,JP,KP,KR,MN,NO,NZ,PL,RO,RU,SE,SK,US

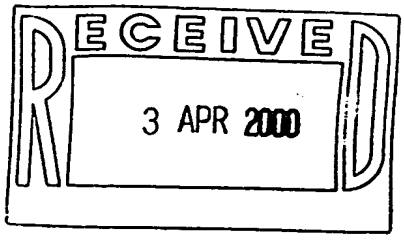
2. The following Offices have waived the requirement for the notification of their election; the notification will be sent to them by the International Bureau only upon their request:

   EA :AM,AZ,BY,KG,KZ,MD,RU,TJ,TM
   OA :BF,BJ,CF,CG,CI,CM,GA,GN,GW,ML,MR,NE,SN,TD,TG
   National :AE,AL,AM,AT,AZ,BA,BB,BY,CH,CR,CU,DK,DM,EE,ES,FI,GB,GD,GE,GH,GM,
   HR,HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MW,MX,PT,SD,SG,SI,
   SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW

3. The applicant is reminded that he must enter the "national phase" **before the expiration of 30 months from the priority date** before each of the Offices listed above. This must be done by paying the national fee(s) and furnishing , if prescribed, a translation of the international application (Article 39(1)(a)), as well as, where applicable, by furnishing a translation of any annexes of the international preliminary examination report (Article 36(3)(b) and Rule 74.1).

   Some offices have fixed time limits expiring later than the above-mentioned time limit. For detailed information about the applicable time limits and the acts to be performed upon entry into the national phase before a particular Office, see Volume II of the PCT Applicant's Guide.

   The entry into the European regional phase is postponed **until 31 months from the priority date** for all States designated for the purposes of obtaining a European patent.



The International Bureau of WIPO
34, chemin des Col mbettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer:
Olivia RANAIVOJAONA

Telephone No. (41-22) 338.83.38

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

International Filing Date

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)*

Box No. I TITLE OF INVENTION

MONOCLONAL ANTIBODY INHIBITOR OF GM-CSF, IL-3 AND IL-5 AND OTHER CYTOKINES AND USES THEREOF

Box No. II APPLICANT

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

MEDVET SCIENCE PTY LTD
Level 3 South Wing
IMVS Building
Frome Road
Adelaide South Australia 5000
AUSTRALIA

☐ This person is also inventor.

Telephone No.
08 82223777

Facsimile No
08 82223779

Teleprinter No

State *(that is, country)* of nationality:
AUSTRALIA

State *(that is, country)* of residence:
AUSTRALIA

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

LOPEZ, Angel
C/- Hanson Centre for Cancer Research
Institute of Medical and Veterinary Science
Division of Human Immunology
Frome Road
Adelaide South Australia 5000 AUSTRALIA

This person is:
☐ applicant only
☒ applicant and inventor
☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:
AUSTRALIA

State *(that is, country)* of residence:
AUSTRALIA

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE: OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name: for a legal entity, full official designation. The address must include postal code and name of country.)*

A.P.T. Patent and Trade Mark Attorneys
GPO Box 772
Adelaide South Australia 5001
AUSTRALIA

Telephone No.
08 84105040

Facsimile No.
08 84105042

Teleprinter No

☐ Address for correspondence: Mark this check-box where no agent or common representative is has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

D'ANDREA, Richard
C/- Hanson Centre for Cancer Research
Institute of Medical and Veterinary Science
Division of Human Immunology
Frome Road
Adelaide South Australia 5000 AUSTRALIA

This person is:
- [ ] applicant only
- [X] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality: AUSTRALIA

State *(that is, country)* of residence: AUSTRALIA

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [X] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence.

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- [ ] applicant only
- [ ] applicant and inventor
- [ ] inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of:
- [ ] all designated States
- [ ] all designated States except the United States of America
- [ ] the United States of America only
- [ ] the States indicated in the Supplemental Box

- [ ] Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☒ AP **ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ EA **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ EP **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ OA **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- ☒ AL Albania
- ☒ AM Armenia
- ☒ AT Austria
- ☒ AU Australia
- ☒ AZ Azerbaijan
- ☒ BA Bosnia and Herzegovina
- ☒ BB Barbados
- ☒ BG Bulgaria
- ☒ BR Brazil
- ☒ BY Belarus
- ☒ CA Canada
- ☒ CH and LI Switzerland and Liechtenstein
- ☒ CN China
- ☒ CU Cuba
- ☒ CZ Czech Republic
- ☒ DE Germany
- ☒ DK Denmark
- ☒ EE Estonia
- ☒ ES Spain
- ☒ FI Finland
- ☒ GB United Kingdom
- ☒ GE Georgia
- ☒ GH Ghana
- ☒ GM Gambia
- ☒ GW Guinea-Bissau
- ☒ HR Croatia
- ☒ HU Hungary
- ☒ ID Indonesia
- ☒ IL Israel
- ☒ IS Iceland
- ☒ JP Japan
- ☒ KE Kenya
- ☒ KG Kyrgyzstan
- ☒ KP Democratic People's Republic of Korea
- ☒ KR Republic of Korea
- ☒ KZ Kazakhstan
- ☒ LC Saint Lucia
- ☒ LK Sri Lanka
- ☒ LR Liberia
- ☒ LS Lesotho
- ☒ LT Lithuania
- ☒ LU Luxembourg
- ☒ LV Latvia
- ☒ MD Republic of Moldova
- ☒ MG Madagascar
- ☒ MK The former Yugoslav Republic of Macedonia
- ☒ MN Mongolia
- ☒ MW Malawi
- ☒ MX Mexico
- ☒ NO Norway
- ☒ NZ New Zealand
- ☒ PL Poland
- ☒ PT Portugal
- ☒ RO Romania
- ☒ RU Russian Federation
- ☒ SD Sudan
- ☒ SE Sweden
- ☒ SG Singapore
- ☒ SI Slovenia
- ☒ SK Slovakia
- ☒ SL Sierra Leone
- ☒ TJ Tajikistan
- ☒ TM Turkmenistan
- ☒ TR Turkey
- ☒ TT Trinidad and Tobago
- ☒ UA Ukraine
- ☒ UG Uganda
- ☒ US United States of America
- ☒ UZ Uzbekistan
- ☒ VN Viet Nam
- ☒ YU Yugoslavia
- ☒ ZW Zimbabwe

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

☒ CR Costa Rica ☒ DM Dominica ☒ Grenada ☒ India ☒ South Africa ☒ United Arab Emirates

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) (13/08/1998) 13 August 1998	PP5251	AUSTRALIA		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s): (1)

** Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*: ISA /

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority)*: Date *(day/month/year)* Number Country *(or regional Office)*

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following number of sheets:

request	:	4
description (excluding sequence listing part)	:	27
claims	:	4
abstract	:	1
drawings	:	14
sequence listing part of description	:	
Total number of sheets	:	50

This international application is accompanied by the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological material
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☒ other *(specify)*: Rule 13bis form

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

For and on behalf of
Medvet Science Pty Ltd

Angel Lopez

Richard D'Andrea

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid.

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
A.P.T. PATENT & TRADE MARK ATTORNEYS
G.P.O. B x 772
Adelaide, S.A. 5001
AUSTRALIE

Date of mailing (day/month/year) 24 February 2000 (24.02.00)	
Applicant's or agent's file reference 1320 PCT	**IMPORTANT NOTICE**

International application No.	**International filing date** (day/month/year)	**Priority date** (day/month/year)
PCT/AU99/00659	13 August 1999 (13.08.99)	13 August 1998 (13.08.98)

Applicant
MEDVET SCIENCE PTY. LTD. et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,CN,EP,IL,JP,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CR,CU,CZ,DE,DK,DM,EA,EE,ES,FI,GB,GD,GE,GH, GM,HR,HU,ID,IN,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT, RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZA,ZW
   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require th applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   24 February 2000 (24.02.00) under No. WO 00/09561

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

Th International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile N . (41-22) 740.14.35

Auth rized fficer
J. Zahra

T lephon N . (41-22) 338.83.38

The demand must be filed directly with the competent International Preliminary Examining Authority or if two or more Authorities are competent, with the one chosen by the applic... The full name or two-letter code of that Authority ... be in... ted by the applicant on the line below:

IPEA/ _____

PCT

CHAPTER II

DEMAND

under Article 31 of the Patent Cooperation Treaty:

The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only

Identification of IPEA	Date of receipt of DEMAND

Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION		Applicant's or agent's file reference
International application No.	International filing date *(day/month/year)*	(Earliest) Priority date *(day/month/year)*
PCT/AU99/00659	13th August 1999	13th August 1998

Title of invention
MONOCLONAL ANTIBODY INHIBITOR OF GM-CSF, IL-3 and IL-5 and OTHER CYTOKINES and USES THEREOF

Box No. II APPLICANT(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

MEDVET SCIENCE PTY LTD
Level 3 South Wing
IMVS Building
Frome Road
Adelaide South Australia 5000
AUSTRALIA

Telephone No.: 08 8222 3777
Facsimile No.: 08 8222 3779
Teleprinter No.:

State *(that is, country)* of nationality: AUSTRALIA

State *(that is, country)* of residence: AUSTRALIA

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

LOPEZ, Angel
C/- Hanson Centre for Cancer Research
Institute of Medical and Veterinary Science
Division of Human Immunology
Frome Road
Adelaide, South Australia 5000
AUSTRALIA

(Applicant for the) (United States only)

State *(that is, country)* of nationality: AUSTRALIA

State *(that is, country)* of residence: AUSTRALIA

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

D'ANDREA, Richard
C/- Hanson Centre for Cancer Research
Institute of Medical and Veterinary Science
Division of Human Immunology
Frome Road
Adelaide, South Australia 5000
AUSTRALIA

(Applicant for the) (United States only)

State *(that is, country)* of nationality: AUSTRALIA

State *(that is, country)* of residence: AUSTRALIA

☐ Further applicants are indicated on a continuation sheet.

International application No.
PCT/AU99/00659

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is [x] agent [ ] common representative

and [x] has been appointed earlier and represents the applicant(s) also for international preliminary examination.

[ ] is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.

[ ] is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

A.P.T. Patent and Trade Mark Attorneys
GPO Box 772
ADELAIDE
SOUTH AUSTRALIA 5001
AUSTRALIA

Telephone No.: 08 8410 5040

Facsimile No.: 08 8410 5042

Teleprinter No.:

[ ] Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION

Statement concerning amendments:*

1. The applicant wishes the international preliminary examination to start on the basis of:

[ ] the international application as originally filed

the description
- [x] as originally filed
- [ ] as amended under Article 34

the claims
- [x] as originally filed
- [ ] as amended under Article 19 (together with any accompanying statement)
- [ ] as amended under Article 34

the drawings
- [x] as originally filed
- [ ] as amended under Article 34

2. [ ] The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. [ ] The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: English

- [x] which is the language in which the international application was filed.
- [ ] which is the language of a translation furnished for the purposes of international search.
- [ ] which is the language of publication of the international application.
- [ ] which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

Box No. V ELECTION OF STATES

The applicant hereby elects all eligible States *(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

excluding the following States which the applicant wishes not to elect:

International application No.
PCT/AU99/00659

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:			For International Preliminary Examining Authority use only: received	not received
1. translation of international application	:	sheets	☐	☐
2. amendments under Article 34	:	sheets	☐	☐
3. copy (or, where required, translation) of amendments under Article 19	:	sheets	☐	☐
4. copy (or, where required, translation) of statement under Article 19	:	sheets	☐	☐
5. letter	:	sheets	☐	☐
6. other *(specify)*	:	sheets	☐	☐

The demand is also accompanied by the item(s) marked below:

1. [X] fee calculation sheet
2. [ ] separate signed power of attorney
3. [ ] copy of general power of attorney; reference number, if any:
4. [ ] statement explaining lack of signature
5. [ ] nucleotide and or amino acid sequence listing in computer readable form
6. [ ] other *(specify)*:

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).

MEDVET SCIENCE PTY LTD
By their Patent Attorney
A.P.T. Patent and Trade Mark Attorneys

Paul Wyk Patent Attorney

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:
2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):
3. [ ] The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. [ ] The applicant has been informed accordingly.
4. [ ] The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.
5. [ ] Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

For International Bureau use only

Demand received from IPEA on:

PATENT COOPERATION TREATY

From the:
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

A.P.T. PATENT AND TRADE MARK ATTORNEYS
GPO Box 772
ADELAIDE SA 5001

PCT

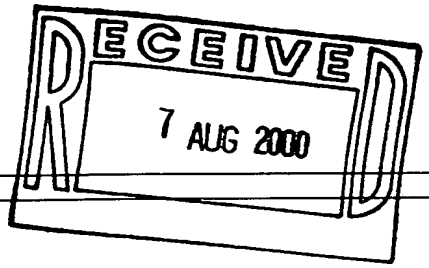
NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *day/month/year*	-3 AUG 2000
Applicant's or agent's file reference: 1320PCT	**IMPORTANT NOTIFICATION**

International application No.	International filing date	Priority date
PCT/AU99/00659	13 August 1999	13 August 1998

Applicant
MEDVET SCIENCE PTY LTD et al



1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translations to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide

Name and mailing address of the IPEA/AU	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	GAVIN THOMPSON Telephone No. (02) 6283 2240

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 1320PCT	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416).
International application No. PCT/AU99/00659	International filing date *(day/month/year)* 13 August 1999	Priority Date *(day/month/year)* 13 August 1998
International Patent Classification (IPC) or national classification and IPC **Int. Cl.** [7] C07K 16/24 16/28		
Applicant MEDVET SCIENCE PTY LTD et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 8 sheet(s).

3. This report contains indications relating to the following items:

I	☒	Basis of the report
II	☐	Priority
III	☐	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
IV	☐	Lack of unity of invention
V	☒	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
VI	☐	Certain documents cited
VII	☐	Certain defects in the international application
VIII	☒	Certain observations on the international application

Date of submission of the demand	Date of completion of the report
23 February 2000	1 August 2000
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **GAVIN THOMPSON** Telephone No. (02) 6283 2240

INTERNATIONAL PRE[illegible]INARY EXAMINATION REPORT

Ir[illegible]ational application No.
PCT/AU99/00659

I. Basis of the report

1. With regard to the **elements** of the international application:*

- [ ] the international application as originally filed.
- [X] the description, pages **1 to 27** as originally filed,
  pages , filed with the demand,
  pages , received on with the letter of
- [X] the claims, pages **28** as originally filed,
  pages , as amended (together with any statement) under Article 19,
  pages , filed with the demand,
  pages **29 to 32** received on **19 October 1999** with the letter of **19 October 1999**
- [X] the drawings, pages **1, 3, 6 to 8, 10 to 14,** as originally filed,
  pages filed with the demand, 3
  pages **2, 4, 5, 9** received on **14 October 1999** with the letter of **13 October 1999**
- [ ] the sequence listing part of the description:
  pages , as originally filed
  pages , filed with the demand
  pages , received on with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

- [ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- [ ] the language of publication of the international application (under Rule 48.3(b)).
- [ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, was on the basis of the sequence listing:

- [ ] contained in the international application in written form.
- [ ] filed together with the international application in computer readable form.
- [ ] furnished subsequently to this Authority in written form.
- [ ] furnished subsequently to this Authority in computer readable form.
- [ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- [ ] The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. [ ] The amendments have resulted in the cancellation of:
   - [ ] the description, pages
   - [ ] the claims, Nos.
   - [ ] the drawings, sheets/fig.

5. [ ] This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	21 to 27	YES
	Claims	1 to 20 and 28 to 31	NO
Inventive step (IS)	Claims	21 to 27	YES
	Claims	1 to 20 and 28 to 31	NO
Industrial applicability (IA)	Claims	1 to 31	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

NOVELTY (N) Claims 1 to 9, 11 to 20 and 28 to 31

D1: AU 15366/97 (706462) B (MEDVET SCIENCE PTY. LTD.) 22 August 1997

This citation discloses the preparation of a monoclonal antibody which inhibits the binding of IL-3, GM-SCF and IL-5 with the Beta-c receptor. The inoculating of the animal with a Beta-c receptor with a domain 4(page 7 line 16) begins the antibody preparartion(page 8 line 34 to page 9 line 4).

INVENTIVE STEP (IS) CLAIMS 1 to 9, 11 to 20 and 28 to 31

As above.

NOVELTY (N) Claim 10

D1: citation as above.

D2: BLOOD, Volume 80, No. 9, November 21, (U.S.), Watanabe Y. et al, "Monoclonal Antibody Against the Common Beta Subunit of the Human Interleukin-3 (IL-3), IL-5 and Granulocyte-Macrophage Colony-Stimulating Factor Receptors Shows Upregulation of Beta C by IL-1 and Tumour Necrosis Factor-Alpha", pages 2215-2220.

D3: MOLECULAR AND CELLULAR BIOLOGY, Volume 16, No. 6, June 1996, (U.S.), Stomski.F. C. et.al, "Human Interleukin-3 (IL-3) Induces Disulfide-Linked IL-3 Receptor alpha- and beta- Chain Heterodimerization. Which is required for Receptor Activation but Not High-Affinity Binding", pages 3035-3046.

These citations disclosed the preparation of monoclonal antibodies that block the binding of IL-3 from the Beta-c receptor. In D2, see the first paragraph of *Cell lines, media and cytokines* and in D3, see lines 9 to 11 of the abstract. As shown by the text above, D1 anticipates this claim also.

INVENTIVE STEP (IS) Claim 10

As above.

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

The incorrectly numbered claim pages 29 to 32 of 19 October 1999 do not completely overlap the lodged claim pages 28 to 31. With the lodged page 28 not replaced, there are two sets of claims 1 to 6.

Claims 10 and 28 are not clear as they do not relate to one invention.

Claim 19 is not clear as the difference between it and claim 18 is non-existent.

Claim 1 is not supported by the description as the cytokine, or portion, of the first step should only have domain 4(page 3 line 19), but in the claim it has at least domain 4 (pages 28,29 lines 5 to 7).

ATENT COOPERATION T[redacted]TY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 16 March 2000 (16.03.00)	
International application No. PCT/AU99/00659	**Applicant's or agent's file reference**
International filing date (day/month/year) 13 August 1999 (13.08.99)	**Priority date** (day/month/year) 13 August 1998 (13.08.98)
Applicant LOPEZ, Angel et al	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   23 February 2000 (23.02.00)

   [ ] in a notice effecting later election filed with the International Bureau on:

   _____

2. The election [X] was

   [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Olivia RANAIVOJAONA

Telephone No.: (41-22) 338.83.38

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00659

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: C07K 16/24 16/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07K 16/24 16/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MEDLINE, CA, WPIDS through STN. Keywords: Monoclonal(w)antibod, Beta C, Beta Subunit, Cytokine.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 15346/97 (706462) B (MEDVET SCIENCE PTY. LTD.) 22 August 1997 see the abstract and claim 1	1 - 31
A	BLOOD, Volume 80, No. 9, November 1 1992, (U.S.), Watanabe Y et al. "Monoclonal Antibody Against the Common Beta Subunit of the Human Interleukin-3 (IL-3), IL-5, and Granulocyte-Macrophage Colony-Stimulating Factor Receptors Shows Upregulation of Beta C by IL-1 and Tumour Necrosis Factor-Alpha", pages 2215-2220 see the abstract and results	1 - 31

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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NTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
A	MOLECULAR AND CELLULAR BIOLOGY, Volume 16, No 6, June 1996, (U.S.), Stomski, F. C et al., "Human Interleukin-3 (IL-3) Induces Disulfide-Linked IL-3 Receptor alpha- and beta-Chain Heterodimerization, Which Is Required for Receptor Activation but Not High-Affinity Binding", pages 3035-3046 see the abstract	1 - 31
A	BLOOD, Volume 90, No. 8, 15 October 1997, (U.S.), Woodcock, J. M. et al. "The Human Granulocyte-Macrophage Colony-Stimulating Factor (GM-SCF) Receptor Exists as a Preformed Receptor Complex That Can Be Activated By GM-SCF, Interleukin-3, or Interleukin-5", pages 3005-3017 see the abstract	1 - 31
A	IMMUNOLOGIC RESEARCH, Volume 13, Nos. 2,3; 1994, (U.S.), Von Feldt, J. M. et al. "Granulocyte-Macrophage Colony-Stimulating Factor Mimicry And Receptor Interactions", pages 96-109 see the abstract	1 - 31

INTERNATIONAL SEARCH REPORT
Information on patent family members

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This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member		
AU 706463	AU15366/97	WO9728190	EP 889905

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(54) Title: MONOCLONAL ANTIBODY INHIBITOR OF GM-CSF, IL-3, IL-5 AND OTHER CYTOKINES, AND USES THEREOF

(57) Abstract

A method of isolating a monoclonal antibody capable of inhibiting any one of IL-3, GM-CSF and IL-5 binding to the common receptor β_c, or a monoclonal antibody capable of inhibiting the cytokines binding to a receptor analogous to β_c. The method includes the steps of immunising an animal with a cytokine receptor or portion of a cytokine containing the critical binding site which portion includes the extracellular domain 4 or analogous domain in the analogous common receptor or part thereof. Antibodies producing cells from the animal are then isolated and fused with a myeloma cell line and then screened for a cell line that produces an antibody of the desired type. A monoclonal antibody, or fragments thereof capable of inhibiting the binding of the cytokines IL-3, GM-CSF and IL-5 to the β_c receptor, and a hybridoma cell line producing the antibody are also claimed.

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MONOCLONAL ANTIBODY INHIBITOR OF GM-CSF, IL-3, IL-5 AND OTHER CYTOKINES, AND USES THEREOF

FIELD OF THE INVENTION

This invention relates to a method of isolating monoclonal antibody inhibitors and reagents derived therefrom and other inhibitors of cytokine binding including monoclonal antibodies and reagents derived therefrom and small molecules capable of inhibiting binding of GM-CSF, IL-3 and IL-5 to the common beta receptor subunit.

INTRODUCTION

Human interleukin (IL)-5, IL-3 and granulocyte-macrophage colony-stimulating factor (GM-CSF) are cytokines involved in hemopoiesis and inflammation (Metcalf; 1986). All three cytokines stimulate eosinophil production, function and survival (Metcalf; 1986) and therefore have the ability to influence inflammatory diseases such as asthma, atopic dermatitis and allergic rhinitis where the eosinophil plays a major effector role. IL-5, being the eosinophil specific cytokine, has received most of the initial attention with IL-5 mRNA and protein levels noted to be elevated in lung tissue and bronchoalveolar lavage (BAL) fluid from symptomatic asthma patients (Fukuda *et al* 1994). Correlation between IL-5 levels and allergen challenge and disease activity have also been seen (Sur *et al*, 1996). It is becoming apparent, however, that not only IL-5 but also GM-CSF and IL-3 play a role in eosinophil production and activation in asthma as there is evidence of both GM-CSF and IL-3 being synthesized at sites of allergic inflammation (Bagley *et al*, 1997b; Allen *et al* 1997). It is possible that expression of these cytokines contributes to the total number of infiltrating eosinophils and the degree of eosinophil activation. Alternatively, they may be responsible for different phases of eosinophil infiltration. Recent kinetic data from patients undergoing antigen challenge showed that IL-5 levels increased between days 2-7 post challenge, whilst GM-CSF peaked at day 2, and remained elevated throughout day 16. Furthermore, GM-CSF detection extended beyond the site of allergen challenge.

IL-5, GM-CSF and IL-3 stimulate eosinophils and other normal and cancer cells by binding to cell surface receptors that comprise a ligand-specific α chain and a β chain which is shared by the three receptors (βc) (Bagley *et al* 1997a). Binding to each receptor α chain is the initial step in receptor activation, however, engagement of either α chain alone is not sufficient for activation to occur. Recruitment of βc

by each ligand: α chain complex follows, a step that has two major functional consequences: firstly, it allows the binding of IL-5, GM-CSF and IL-3 to become essentially irreversible; and secondly, it leads to full receptor activation (Bagley *et al* 1997a). Since βc is the major signalling component of these receptors its engagement leads to the activation of JAK-2, STAT-5 and other signalling molecules culminating in the full plethora of cellular activities commonly associated with either IL-5, GM-CSF and IL-3 stimulation such as eosinophil adherence, priming for degranulation and cytotoxicity, and prolongation of viability (Bates *et al*, 1996).

In order to block or antagonize the activity of eosinophil-activating cytokines *in vivo* three major approaches are being tried. One of them utilizes antibodies to the implicated cytokines. For example, antibodies to IL-5 are being used in an animal model of allergen-induced asthma and have shown to have a relatively long lasting effect in preventing eosinophil influx into the airways and bronchial hyperresponsiveness (Mauser *et al*, 1995). A second approach relies on IL-5 or GM-CSF mutants which can bind to the respective α chains with wild type affinity but which have lost or shown reduced ability to interact with human βc. IL-5 mutants such as E13Q, E13K and E13R, and the human GM-CSF mutant E21R directly antagonize the functional activation of eosinophils by IL-5 or GM-CSF respectively (Tavernier *et al* 1995; McKinnon *et al* 1997; Hercus *et al* 1994b). However, at least in the case of E13K, eosinophil survival is not antagonized and in fact this mutant is able to support eosinophil survival (McKinnon *et al* 1997). A third approach involves the use of soluble receptor α chains which can sequester circulating cytokines. However, this carries the risk of a cytokine:receptor α chain complex potentially interacting with surface-expressed βc and triggering receptor activation. The common theme amongst these approaches is that they tackle a single receptor system involving either IL-5, GM-CSF or IL-3 leaving the other two eosinophil-acting cytokines unaffected. Although the concomitant administration of IL-5 and GM-CSF antagonists may be considered, this may be clinically impracticable.

An alternative approach to blocking eosinophil-activating cytokines involves targeting the common β chain of their receptors. Although βc does not directly bind IL-5, GM-CSF or IL-3 alone, it does bind to these cytokines complexed to the appropriate receptor α chain. Lopez *et al* in WO 97/28190, which is incorporated herein by reference in its entirety, have identified the major binding

sites of, βc for the IL-5:IL-5Rα, GM- CSF:GM-CSFRα and IL-3:IL-3Rα complexes. Significantly, these sites are utilized by all three complexes and comprise the predicted B'-C' loop and F'-G' loop in βc. Thus targeting βc is not only desirable but also feasible, with the added potential to allow the simultaneous inhibition of IL-5, GM-CSF and IL-3 action by a single agent. These workers have shown that certain mutants in the B'-C' and the F'-G' loop fail to bind IL-5, GM-CSF and IL-3.

SUMMARY OF THE INVENTION

The present invention results from the isolation of a monoclonal antibody (BION-1) raised against the membrane proximal domain (domain 4) of βc which is able to block the production and activation of human eosinophils stimulated by IL-5, GM-CSF or IL-3 and blocks the growth of leukaemic cell lines. This MoAb was able to block the high affinity binding of all three cytokines to eosinophils by binding to residues in the predicted B'-C' and F'-G' loops of βc, and prevented receptor dimerization and βc phosphorylation. It was found that raising an antibody capable of blocking the binding of all three cytokines was possible by screening monoclonal antibody-expressing hybridoma cell lines arising from immunising mice with cells expressing only domain 4 of β_c and lacking domains 1 to 3 and expressing domain 4 and the transmembrane and cytoplasmic regions.

Additionally this finding is likely to have implications for other members of the cytokine receptor superfamily some of which are shared subunits in a given subfamily (that is they bind several cytokines), and some which are ligand specific and bind to only one cytokine. The receptor α-chains for GM-CSF, IL-3 and IL-5 and β_c belong to the rapidly expanding cytokine receptor superfamily. Within this superfamily several sub-families are now emerging that are characterized by the sharing of a communal receptor subunit by multiple ligands: gp130 acts as an affinity converter and signal transducer for IL-6 (Hibi *et al.*, 1990; Taga *et al.*, 1992), IL-11 (Hilton *et al.*, 1994), oncostatin M (Liu *et al.*, 1992), ciliary neurotrophic factor, leukaemia inhibitory factor (LIF) (Ip *et al.*, 1992) and cardiotrophin-1(Pennica *et al.*, 1995); the LIF receptor (LIFR) also binds ciliary neurotrophic factor (Davis *et al.*, 1993), cardiotrophin-1 (Pennica *et al.*, 1995) and oncostatin M in addition to LIF (Gearing *et al.*, 1994); IL-2R β supports affinity conversion and signalling of IL-2 and IL-15 (Giri *et al.*, 1994); IL-2R γ chain affinity converts IL-2 (Takeshita *et al.*, 1992), IL-4 (Russell *et al.*, 1993), IL-7 (Noguchi *et al.*, 1993), IL-9 (Kimura *et al.*, 1995) and IL-15 (Giri *et al.*, 1994);

evidence also suggests that IL-4 and IL-13 share a receptor component (Zurawski *et al.*, 1993) and this subunit has recently been cloned (Hilton *et al.*, 1996). It is not known which residues in gp130, LIFR and IL-2R β and γ chains are important for ligand binding or indeed whether different ligands share or have unique sets of binding determinants on these communal receptor subunits. Because these common subunits are vital for transducing signals by several ligands, the possibility arises that interfering with the ability of these common subunits to bind ligand or to form homodimers may affect the action of more than one ligand.

Clear similarities in structure between β_c and other cytokine receptors have been recognised and similarities in at least part of the binding site, the F'-G' loop, have been identified in Lopez *et al* in WO 97/28190. Accordingly it is an expectation that the means employed by the inventors to obtain a monoclonal antibody that inhibits binding of IL-3, GM-CSF and IL-5 will also lead to the isolation of monoclonal antibodies that inhibit binding of other cytokines to their respective receptors.

In a broad form of a first aspect the invention could be said to reside in a method of isolating a monoclonal antibody capable of inhibiting any one of IL-3, GM-CSF and IL-5 binding to the common receptor β_c, or a monoclonal antibody capable of inhibiting a cytokines binding to a receptor analogous to β_c, said method comprising the step of immunising an animal with a cytokine receptor or portion of a cytokine receptor containing the critical binding site which portion might include the extracellular domain 4 or analogous domain in the analogous common receptor or part thereof, isolating antibody producing cells from said animal and fusing antibody producing cells with a myeloma cell line, screening for a cell line that produces an antibody of the desired type.

The immunisation may involve introducing a cDNA clone of a portion of or all of the common receptor including the extracellular domain 4 or analogous domain in the analogous common receptor or part thereof, into a cell and proliferating said cells to form a recombinant cell line, inoculating an animal with said recombinant cell line, isolating antibody producing cells from said animal and fusing the antibody producing cell line with a myeloma cell line to form a hybridoma cell line, screening for a hybridoma cell line that produces an antibody that binds to the recombinant cell line but not to the parent, and then testing for inhibition against all

three cytokines. In one form the cell into which the cDNA clone is introduced is mammalian and one commonly used mammalian cell line is a COS cell.

The cDNA may encode a full or partial portion of domain 4 when it is in a configuration where the F'-G' loop and/or the B'-C' loop is in its native shape. The data below show that cDNA encoding substantially only domain 4 of the extracellular portion of β_c as well as the transmembrane and the intracellular portions maintains these sites in a sufficiently integral conformation so that an antibody raised thereagainst will give the inhibition sought. It is postulated that the same will be the case for analogous receptors for the cytokine superfamily. This method should be distinguished from immunising with the whole receptor since the extracellular domain 4 is likely to be covered or masked by other domains in the whole receptor.

β_c has two repeats of the cytokine receptor module (CRM), each of which has two discrete folding domains (CRDs), so that in total β_c has 4 domains hence named domains 1 to 4 (β1 to 4). It is postulated that domain 2 of any CRM may be an equivalent of domain 4 and therefore domain 2 may be used in the immunisation.

In addition the domain 4 of β_c or equivalent domain in other cytokine receptors may be expressed in isolation in a microbial host such as *Escherichia coli* and used to immunise animals for developing monoclonal antibodies.

The analogous receptor may be any one of the cytokine superfamily receptors but not limited to the group comprising β_c, LIFR, gp130, IL-2Rβ, IL-4R/IL-13R, IL-2Rγ, IL-3Rα, EPOR, TPOR and OBR.

It will be understood that in one specific form of this aspect of the invention the method is used to isolate a monoclonal antibody that inhibits cytokine binding to a common receptor subunit. The common receptor is envisaged to be selected from the group of receptors acting for more than one cytokine including but not limited to gp130, LIFR, IL2Rβ/IL2Rα, and IL-4R/IL-13R in addition to β_c.

It will also be understood that the invention encompasses monoclonal antibodies or fragments thereof produced as a result of this first form of the invention.

In a broad form of a second aspect the invention could be said to reside in a monoclonal antibody, or fragments thereof capable of inhibiting the binding of the three cytokines IL-3, GM-CSF and IL-5 to the β_c receptor.

The degree of inhibition may range from complete inhibition to moderate inhibition, which inhibition will of course be dependent on the amount of monoclonal antibody or fragments thereof added to inhibit and the relative affinity of the antibody or fragment thereof to the β_c.

The extent of inhibition of respective ones of the three cytokines is not necessarily identical and may vary, so the different cytokines may be inhibited from binding to different degrees.

The antibody fragments may be larger portions such as Fab fragments or much smaller fragments of the variable region. These fragments may be used as separate molecules or alternatively may form part of a recombinant molecule which is then used for therapeutic purposes. Thus for example the monoclonal antibody may be "humanised" by recombining nucleic acid encoding the variable region of the monoclonal antibody with nucleic acid encoding non-variable regions of human origin in an appropriate expression vector.

The inhibition preferably leads to blocking of at least one function of all three cytokines. One of the benefits that is proposed to be derived from these antibodies or antibody fragments is their use in modifying cells stimulated by one of the three cytokines, and more in one specific form modifying the activity of the three cytokines is proposed to impact greatly on eosinophil function. Therefore preferably the activity leads to inhibition of stimulation of effector cell activation and where the antibody or fragment thereof is to be used for treatment of asthma leads most preferably to inhibition of IL-5, IL-3 & GM-CSF mediated eosinophil activation. It will be understood however that cells other than eosinophils are also the effectors of adverse conditions in humans and animals as a result of stimulation by these cytokines and inhibition of such stimulation is also contemplated by this invention. These include cells that express either one or all of GM-CSF, IL-3 and IL-5 receptors, the stimulation of which leads to pathology. Examples of these are leukaemic cells, endothelial cells, breast cancer cells, prostate cancer cells, small cell lung carcinoma cells, colon cancer cells, macrophages in chronic inflammation

such as rheumatoid arthritis, dendritic cells for immunosuppression and neutrophils in inflammation.

Thus in one form the invention may be said to reside in an inhibitor of leukaemic cell growth wherein the inhibitor is capable of inhibiting the binding of one or all of IL-3, GM-CSF and IL-5 to the β_c receptor. The inhibitor may be BION-1 or an agent capable of inhibiting BION-1 binding with β_c.

A number of different facets of eosinophil function might be modified so that in one form IL-5, IL-3 & GM-CSF mediated eosinophil survival is inhibited or blocked. In a second form IL-5, IL-3 and GM-CSF mediated eosinophil activation is inhibited or blocked.

In one form of this second aspect of the invention the monoclonal antibody or fragment thereof binds to at least the F'-G' loop of domain 4 of the β_c subunit.

In an alternative form the monoclonal antibody or fragment thereof binds to at least the B'-C' loop of domain 4 of the β_c subunit but this alternative form is not limited to monoclonal antibodies or fragments thereof that only bind to the F'-G' loop but includes monoclonal antibodies or fragments thereof that perhaps binds to both the F'-G' as well as the B'-C' loop of domain 4 of the β_c.

It is thought that the monoclonal antibody isolated by the inventors inhibits dimerisation of the common receptor units and thus the invention might encompass an antibody or fragments thereof of the second aspect of the invention that inhibit β_c receptor dimerisation.

In one very specific form the monoclonal antibody is the antibody produced by the hybridoma cell line BION-1 (ATCC HB-12525).

In a broad form of a third aspect the invention could be said to reside in a hybridoma cell line capable of producing a monoclonal antibody of any form of the first or second aspect of the invention.

In one specific form of the third aspect of the invention the hybridoma cell line is BION-1 (ATCC HB-12525).

Since GM-CSF, IL-3 and IL-5 need to bind their respective α chains before being able to interact with β_c, at present most screening for new inhibitors utilise cell-based assays where both, α and β_c receptor units are co-expressed. Solid phase assays rely on inhibition of GM-CSF, IL-3 or IL-5 to their respective α chain only since these cytokines cannot bind to β_c alone. Since BION-1, unlike these three cytokines, can directly bind to β_c we propose that it can be used as a novel solid phase screening assay. Any compound that binds the appropriate site which is likely to inhibit all three cytokines will also inhibit the binding of BION-1. Additionally once further inhibitory compounds are uncovered these could be used in the place of BION-1 in that screening process. This therefore facilitates the screening of larger number of candidate inhibitor compounds.

In a broad form of a fourth aspect therefore the invention could be said to reside in a method of screening peptides, oligonucleotides and other small molecules for their capacity to competitively inhibit the binding of BION-1 or the binding of an agent capable of inhibiting BION-1 binding, to the β_c subunit.

Generally the screening assay involves contacting BION-1 or fragment thereof with the β_c subunit or fragment thereof as well as a candidate inhibitory compound, and measuring the degree of binding.

A reporting means is preferably provided to facilitate the detection of binding of BION1 or fragment thereof with β_c subunit or fragment thereof. Thus, for example, a competitive binding assay using labelled BION-1 could be used for this purpose. β_c or domain 4 of β_c is immobilized on a plate or tube and several compounds added, followed by labelled or tagged BION-1 or fragments thereof. Since BION-1 binds the region of β_c involved in binding all three cytokines, any compounds that block or reduce the binding of BION-1 or fragments thereof to β_c or domain 4 will be considered candidate inhibitory compounds. Thus, the availability of BION-1 as an agent that for the first time allows the direct binding to the cytokine binding region of β_c affords a novel test for the identification of simultaneous inhibitors of GM-CSF, IL-3 and IL-5. It will be understood that the same will apply for other cytokines and their respective receptors.

It will be understood that not the entire β_c subunit needs be used to screen candidate compounds, and certainly the present data indicates that a fragment of the

β_c subunit encompassing domain 4 has sufficient structure in common with the native β_c subunit to reflect the configuration of the cellular target for an inhibitor useful for an *in vivo* effect.

In a broad form of a fifth aspect, the invention could be said to reside in a cytokine inhibitor capable of simultaneously blocking the binding of β_c by IL-3, GM-CSF, and IL-5 made according to the fourth aspect of the invention.

It is thought that compounds that inhibit binding of the IL-3, IL-5 and GM-CSF to the β_c will be therapeutically useful for intervention in conditions where IL-3, GM-CSF and IL-5 play a pathogenic role, mainly allergy, asthma, acute and chronic myeloid leukaemias, lymphoma and inflammation including rheumatoid arthritis, breast cancer and prostate cancer.

Similarly for other common cytokine receptors it is thought that antagonists or agonists will be therapeutically useful. gp130 is functionally analogous to β_c in that it is a common binding sub-unit and signal transducer for the IL-6, oncostatin M (OSM), ciliary neutrotrophic factor (CNTF), leukaemia inhibitory factor (LIF) and IL-11. It is suggested that raising an antibody against a domain analogous to domain 4 of β_c will also lead to blocking of two or more of these cytokines. Antagonism of this receptor system will be useful in inflammation, leukaemia and lymphoma. Antagonists to IL2Rβ/IL2Rα may be useful as immunosuppresants. Antagonists of LIFR may be useful for the prevention of implantation of embryos in uteri. Antagonists of IL-4/IL-13 will inhibit IgE production and may be useful in treating asthma and allergies.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1. Flow cytometry analysis of the staining of MoAb BION-1 (continuous line) and an isotype matched IgG_1 control MoAb (dotted line) to (A) COS cells transiently transfected with β_c, (B) CHO cells constitutively expressing β_c, (C) TF-1.8 cells, (D) neutrophils, (E) eosinophils and (F) monocytes.

Figure 2. MoAb BION-1 recognizes β_c protein. (A) Immunoprecipitation of β_c from ^{125}I-surface labelled CHO β_c

cell lysate. Both experiments were performed on 7.5% SDS PAGE under reducing conditions. (C) MoAb BION-1, but not another anti-β_c MoAb 1C1, recognises a β_c mutant (β_c-ΔQP) that contains only domain 4 in the extracellular regions by immunoprecipitation of CHO ΔQP cells. This mutant has a flag attached so it can also be seen by anti-flag MoAb M2. The experiment was performed on 10% SDS PAGE under reducing conditions.

Figure 3. Dose-dependent competition for the binding of ^{125}I-IL-5 (50 pM), ^{125}I-GM- CSF (50 pM) and ^{125}I-IL-3 (200 pM) by MoAbs BION-1 (•), an anti-β_c MoAb control ( ), and an IgG_1 control MoAb (o) to TF-1.8 cells ($2x10^6$ per point). (---) represents ligand binding in the presence of 200-fold excess unlabelled ligand. Each point is the mean of triplicate determinations.

Figure 4. A Fab fragment of BION-1 blocks high affinity binding of IL-5, GM-CSF and IL-3. Binding of ^{125}I-IL-5 (50 pM), ^{125}I-GM-CSF (50 pM) and ^{125}I-IL-3 (200 pM) were assessed on TFI.8 cells ($2x10^6$ per point) in the presence or absence of 3000 nM MoAb BION-1, or control anti-β_c MoAb, or 4200 nM Fab fragment of BION-1 for 2 h at room temperature. 1C1 was used as a non blocking anti-β_c control. Cells were separated from unbound radioligand by spinning through FCS and the resulting cell pellet was counted. The results are expressed as a percentage of the total specific cpm bound seen in the absence of antibody. Non-specific binding was determined in the presence of 200 fold excess of cold ligand. Total binding seen for ^{125}I-IL-5, ^{125}I-GM-CSF and ^{125}I-IL-3 were 9744.2, 2567.1 and 3379.13 cpm respectively. Blocking with Fab fragment of BION-1 was determined from a single point and BION-1 and 1C1 values are the mean of duplicate determinations with error bars representing 1 standard deviation.

Figure 5. BION-1 blocks high affinity binding of IL-5, GM-CSF and IL-3 to human eosinophils. Human eosinophils ($1.8x10^6$ per point) were incubated with ^{125}I-IL-5 (10 pM or 3 pM), ^{125}I-GM-CSF (50 pM) or ^{125}I-IL-3 (200 pM) either alone or in the presence of 1μM MoAb at room temperature for 2 h. MoAb's 9E10 and 8E4 were used as isotype matched and non-blocking anti-βc control respectively for BION-1. Cells were separated from unbound radioligand by spinning through FCS and the resulting cell pellet was counted. The results are expressed as a percentage of the total specific cpm bound seen in the absence of antibody. Non-specific binding was determined in the presence of 200 fold excess of cold ligand and was determined to be an average of 0.3% of total counts added. Total binding seen for ^{125}I-IL-5, ^{125}I-GM-CSF and ^{125}I-IL-3 were 765, 622 and 748 cpm respectively. Each point is the mean of duplicate determinations and error bars represent 1 standard deviation.

Figure 6. MoAb BION-1 recognizes an epitope in βc comprising at least residues M363, R364, E366 and R418. Human βc wild type and mutants (Woodcock *et al,* 1996) were tested for reactivity with MoAb BION-1 and 1C1 used as a control. Following expression of wild type βc and βc mutants on COS cells, βc was immunoprecipitated by MoAb 8E4, followed by Western blotting by MoAb BION-1 (top) or the non blocking MoAb 1C1 (bottom).

Figure 7. The binding of ^{125}I-labelled MoAb BION-1 (1 nM)to TF.1 cells is inhibited by IL-3 (•), but not by TNF-α (o). (—) Represents inhibition in the presence of 200-fold excess of unlabelled BION-1.

Figure 8. BION-1 IgG selectively inhibits IL-5, GM-CSF and IL-3 mediated proliferation of TF 1.8 cells. The proliferation experiments represent the comparison of inhibition of BION-1 IgG at maximal dosage (400 μg/ml BION-1 with IL-5 and IL-3 and 850 μg/ml with GM-CSF) against ED^{50}

concentrations for IL-5 (0.3 ng/ml), GM-CSF (0.03 ng/ml) or IL-3 (0.3 ng/ml). An anti-β_c antibody and an irrelevant IgG antibody were used as controls. The results are expressed as DPM. Each value represents the mean of triplicate determinations and error bars represent the SEM.

Figure 9. Fab fragment of BION-1 and BION-1 IgG inhibits IL-5, GM-CSF and IL-3 mediated proliferation of TF1.8 cells. Intact IgG or Fab fragment of BION-1 were titrated against a fixed concentration of IL-5 (0.3 ng/ml), GM-CSF (0.03 ng/ml) or IL- 3 (0.3 ng/ml) in proliferation assays where TF1.8 cells at $5x10^4$/ well were incubated for 48 hours and then pulsed for 5 hours with 0.5 μCi/well ^{3}H-Thymidine. The results are expressed as DPM. Each value represents the mean of triplicate determinations and error bars represent the SEM.

Figure 10. Eosinophil survival. (A) Viability of eosinophil after 36 hours in the presence of IL-5, IL-3 and GM-CSF. (B) Viability of eosinophil after 36 hours in the presence of IL-5, IL-3 and GM-CSF (1 nM) and different concentrations of MoAb BION-1 (o) and 8E4 (•). Each point is the mean of triplicate determinations from three samples and error bars represent 1 standard deviation.

Figure 11. MoAb BION-1 inhibits IL-5-stimulated CD69 up-regulation on human eosinophils. (A) CD69 up-regulation in the presence of different concentrations of IL- 5, IL-3, GM-CSF and TNF-α. (B) CD69 up-regulation stimulated by 1 nM of IL-5, GM- CSF, IL-3 or TNF-α in the presence of different concentrations of MoAb BION-1 or control anti-β_c MoAb 8E4. Each point is the mean value of three replicates and error bars represent 1 standard deviation.

Figure 12. Inhibition of IL-3-induced α and β chain dimerization and phosphorylation by MoAb BION-1. Immunoprecipitations using anti-IL-3Rα MoAb 9F5 or anti-β_c MoAb 8E4 from

M07e cells preincubated with MoAbs BION-1, MoAb 1C1 or medium alone (-) for 1 min, before being stimulated (+) or not (-) with IL-3 (50 nM) for 5 min. The figure was visualised by PhosphorImaging and the position and molecular weight (in thousands) of marker proteins are shown to the left of the gels. The gels were reprobed by Western blotting analysis using anti-phosphotyrosine MoAb 3-365-10 and the top panel shows the image of part of the gels in the β_c area.

Figure 13. Screening peptides for inhibition of MoAb BION-1 binding to soluble β_c domain 4 adsorbed to solid phase. *E. coli* derived soluble β_c domain 4 ($s\beta_c$#4) was coupled to Maxisorp ELISA plates at 10µg/ml in 0.1M carbonate buffer overnight and then blocked with 1% BSA. (A) B45.pep (FHWWWQP-GGGCDYDDDK) (÷) and (B) YB12.pep (FPFWYHAHSPWS-GGGCDYKDDDK) (•) were derived from biopanning libraries with $s\beta_c$#4 using an acid eluant. B45 was allowed the bond to $s\beta_c$#4 at 0.0125µM and YB12 was allowed to bind $s\beta_c$#4 at 0.025µM. BION-1 was added to the plates at a starting concentration of 5µg/ml and serial dilutions were used to titrate the BION-1 down to 0.004µg/ml. The plate was washed again and BION-1 binding to $s\beta_c$#4 was detected.

Figure 14. BION-1 specifically inhibits the growth *in vitro* of chronic myelomonoctic cells (CMML). A contol antibody (1C1) does not inhibit.

DETAILED DESCRIPTION OF THE INVENTION

Materials and Methods

ΔQP cDNA: To express domain 4 of β_c on the cell surface we cloned the activated β_c mutant, $h\beta_c\Delta QP$, with an extracellular deletion removing domains 1 to 3

(D'Andrea *et al* 1996), into the eukaryotic expression vector pcDNA3 (Invitrogen).

Cytokines and cell lines: Recombinant human IL-3 and GM-CSF were produced in *E. coli* as described (Barry *et al*1994, Hercus *et al* 1994b). Recombinant human IL-5 was purified from *E.coli* by Bresatec (Adelaide, South Australia). Recombinant EPO was purchased from Johnson & Johnson (New Jersey). TNFα was a gift from Dr. J. Gamble in the Hanson Centre for Cancer Research. COS cells were transfected with receptor cDNA as described previously (Woodcock *et al* 1994). CHOβc and CHOΔQP cells stably expressing either full length βc or domain 4 respectively were generated by electroporation (Hercus *et al*, 1994a). TF1.8 cells were a gift from Dr J. Tavernier from University of Gent, Belgium. MO7e cells, a human megakaryoblastic cell line, were from Dr P Crozier, Aukland, New Zealand. Human eosinophils were purified from the peripheral blood of slightly eosinophilic volunteers via sedimentation through dextran and centrifugation through a discontinuous density gradient of hypertonic Metrizamide, as previously described (Vadas *et al* 1979). Eosinophils were more than 92% pure. Human neutrophils and monocytes were purified from peripheral blood as described previously (Lopez*et al*, 1990) with more than 95% purity.

Generation of anti-βc MoAbs: BALB/c mice were immunized intraperitonally with $1x10^7$ COS cells transfected with βc or ΔQP expression constructs. ΔQP constructs express substantially only domain 4 of the extracellular domains of βc. The immunizations were repeated 4 times at two-weekly intervals. Four weeks after the final immunization, a mouse was boosted with $2x10^6$ COS transfectants intravenously. Three days later, splenocytes were harvested and fused with NS-1 myeloma cells as previously described (Sun *et al* 1996). Hybridoma supernatants were screened on CHO βc or CHO ΔQP cells by flow cytometry, with untransfected CHO cells as a control. All antibodies were from single hybridoma clones as selected by limiting dilution method. MoAbs were purified from ascites fluid or hybridoma supernatant by a protein A sepharose column. The isotypes of MoAbs were tested with a Mouse MoAb Isotyping Kit (Boehringer Mannheim, Germany). Fab fragments were generated using a Fab Preparation kit (Pierce, Rockford, IL) following the supplied protocol.

Immunofluorescence: Freshly purified neutrophils, eosinophils, monocytes, or CHO and COS cell transfectants ($5x10^5$) were incubated with 50µl of hybridoma supernatant or 0.25mg of purified MoAb for 45-60 min at 4°C. Cells were washed twice and then incubated with FITC-conjugated rabbit anti-mouse Ig (Silenus, Hawthorn, Victoria, Australia) for another 30-45 min. Cells were then washed and fixed before analysing their fluorescence intensity on an EPICS-Profile II Flow Cytometer (Courter Electronics). Two colour staining was carried out by additional incubation with another MoAb directly coupled to PK.

Ligand Binding Assay: IL-3 and GM-CSF were radio-iodinated by the iodine monochloride method (Contreras 1983). ^{125}I-IL-5 was purchased from Dupont NEN (North Sydney, NSW, Australia). Binding assays were performed as previously described (Lopez *et al* 1989). Briefly, $1-2x10^6$ TF-1.8 cells were preincubated with BION-1 Fab fragments, anti-βc or control MoAbs over a concentration range of 0.06 to 4200 nM for 1 hour. Radio-labelled ligand was then added and incubated for a further two hours before the cells were separated from free label by spinning through FCS. Counts associated with the resulting cell pellets were determined by counting on a γ counter (Cobra Auto Gamma; Packard Instruments Co, Meridien, CT). Non-specific binding was determined for each ligand by binding in the presence of a 200 fold excess of unlabelled cytokine.

MoAb binding assay: MoAbs were radio-iodinated by the chloramine-T method (McConahey 1980). Saturation binding studies were performed by incubating $2x10^6$ TF1 cells in a range of concentrations of radio-labelled antibodies in the presence or absence of excess unlabelled antibodies. The binding affinity of each anti-βc MoAb to its antigen was determined by Scatchard transformation (Scatchard 1949) and analysed with the ligand program (Munson and Rodbard, 1980). Competition binding experiments were set up by preincubating the TF1.8 cells with a range concentration of IL-3, or GM-CSF, or IL-5 prior to adding radio-labelled MoAb QP1 for two hours as per ligand binding assay. Epitope analysis was determined by testing the capacity of each unlabelled MoAb to compete for the binding of each radio-labelled MoAb to the βc on COS cell transfectant.

Co-immunoprecipitation of α and β chains and the β_c phosphorylation assays: M07e cells were surface labelled with ^{125}I by the lactoperoxidase method as

described previously (Walsh and Crumpton, 1977). The labelled cells incubated in either medium containing IL-3 (100 ng/ml) alone or IL-3 together with the MoAb QP1, 1C1 (0.5 mg/ml) or 7G3 (30 mg/ml) for 5 min. Cells were lysed in lysis buffer consisting of 137 mM NaCl, 10 mM Tris-HCl (pH 7.4), 10% Glycerol, 1 % Nonindet P40 with protease and phosphatase inhibitors (10 mg/ ml leupeptin, 2mM phenylmethlysulphonyl fluoride, 10 mg/ml aprotonin and 2 mM sodium vanadate) for 30 min at 4°C followed by centrifugation of the lysate at 10,000 x g for 15 min to remove cellular debris. The lysate was precleared with mouse-Ig-coupled Sepharose beads for 18 h at 4°C and incubated with anti-IL-3Ra, anti-βc MoAb beads for 2 hr at 4°C. The beads were washed 6 times with lysis buffer and immunoprecipitated proteins were separated by SDS-PAGE under reducing condition. The immunoprecipitated proteins were detected by a PhosphorImager (Molecular Dynamics, Sunnyvale, CA). The gels were then reprobed by Western blotting analysis with an anti-phosphotyrosine MoAb, 3-365-10 (Boehringer Mannheim, Frankfurt, Germany).

TF-1.8 cell proliferation assay: TF-1.8 cells were grown in the presence of 2 ng/ml of GM-CSF. The cells were starved for 24 hours before setting up proliferation assays as described previously (Sun *et al.*, 1996). From dose-response curves the half-maximal proliferation dosage of IL-3 (0.3 ng/ml), GM-CSF (0.03 ng/ml), IL-5 (0.3 ng/ml) or EPO (5 ng/ml) was chosen to perform proliferation experiments in the presence of a range of concentrations of MoAbs. The ^{3}H-Thymidine incorporation of each sample was determined by liquid scintillation and expressed as disintegrations per minute (DPM).

Eosinophil survival assays: The maximal dose of IL-5 required to support eosinophil survival after 36 hours was determined. Eosinophils were then cultured with 1 nM of IL 5 plus anti-βc MoAbs for 36 hours. The viability of eosinophils was quantitated by propidium iodide staining and flow cytometry analysis as described (Nicoletti, 1991).

CD69 expression: CD69 expression on eosinophils was measured by means of an antiCD69 monoclonal MoAb coupled to PE by flow cytometry.

βc *mutants and MoAb Mapping:* Single amino acid substitutions in the B'-C' and F'- G' loops of domain 4 of the βc have been described previously (Woodcock, *et*

al., 1994; 1996). The cDNAs for wild type βc and each of the βc mutants in the B'-C' and F'-G' loops were introduced into COS cells by the electroporation (Hercus *et al.*, 1994). Cell transfectants were analysed for surface expression with 48 hours after transfection. Mutants on the B' and C' β-strands such as L356N, W358N, I374N and Y376N were expressed on FDCP1 cells from retroviral expression constructs (Jenkins *et al.*, 1995). Epitope-mapping of anti-βc antibodies was analysed by Immunofluorescent study. The anti-βc MoAbs were tested for their abilities to recognise wild type βc and the βc mutants analysed by flow cytometer using standard immunofluorescence method. For each mutant, the experiment was repeated at least twice.

BION-1 binding inhibitory peptides: E. coli derived soluble β_c domain 4 ($s\beta_c$#4) was coupled to Maxisorp ELISA plates at 10μg/ml in 0.1M carbonate buffer overnight and then blocked with 1% BSA. B45.pep (FHWWWQP-GGGCDYDDDK) was derived from four rounds of biopanning the Ph.D-7mer library with $s\beta_c$#4 using an acid eluant. YB12.pep (FPFWYHAHSPWS-GGGCDYKDDDK) was derived from biopanning the Ph.D-12mer library with $s\beta_c$#4 using an acid eluant. B45 was allowed the bond to $s\beta_c$#4 at 0.0125μM and YB12 was allowed to bind $s\beta_c$#4 at 0.025μM. The plate was washed in TBS + 0.5% Tween. BION-1 was added to the plates at a starting concentration of 5μg/ml and serial dilutions were used to titrate the BION-1 down to 0.004μg/ml. The plate was washed again and BION-1 binding to $s\beta_c$#4 was detected with α-mouse conjugated to HRP, using a colour based reaction which was read on a plate counter by absorption.

BION-1 inhibition of chronic myelomonocytic cells: Peripheral blood from a patient with chronic myelomonocytic leukemia was centrifuged over Ficoll-Paque to separate the mononuclear cells. After washing and counting, the cells were plated on agar as a concentration of 10^5 per plate. After incubation in medium containing monoclonal antibodies BION-1 or 1C1, with or without IL-3, for 14 days at 37°C the number of arising colonies were counted by mycroscopical examination. Each cell cluster containing more than 40 cells was counted as a colony.

Results

Development of MoAb BION-1

Previous experiments have shown that the putative F'-G' loop of βc contains a common binding site for IL-5, GM-CSF and IL-3 (Woodcock *et al*, 1996; WO 97/28190). We have now produced a blocking compound, represented by MoAb BION-1, by immunizing mice with COS cells transfected with a cDNA coding for domain 4 of βc. Screening of hybridoma supernatants was performed on a CHO cell line expressing domain 4 of βc. One hybridoma cell line was identified which produced a MoAb which specifically recognized this cell line and not a parental CHO cell line not expressing domain 4 of βc. This MoAb was termed BION-1 and was characterized in biochemical, binding and biological experiments.

BION-1 recognizes domain 4 as well as wild type βc.

MoAb BION-1 was tested for reactivity against cell lines transfected with βc and against primary cells known to express IL-5, GM-CSF and IL-3 receptors. BION-1 recognized COS cells transiently transfected with βc, CHO cells permanently transfected with βc, the erythroleukaemic TF-1 cell line, and purified peripheral blood human neutrophils, eosinophils and monocytes (Figure 1).

The antigen recognized by BION-1 was confirmed to be domain 4 of βc, by biochemical analysis of transfected cells. Figure 2A shows that BION-1 immunoprecipitated a surface ^{125}I-labelled protein of about 120,000 MW consistent with the size of βc. Similarly, BION-1 recognized a protein of 120,000 MW by Western blotting using lysates of CHO cells expressing full length wild type βc (Figure 2B). The size of these bands also corresponded to the bands recognized by a previously developed anti-βc MoAb (Korpelainen *et al* 1993; Woodcock *et al*, 1996). To formally show that BION-1 recognized domain 4 of βc we also tested BION-1 for its ability to immunoprecipitate domain 4 expressed on the surface of CHO cells. As a positive control we incorporated a short polypeptide to the N-terminus of domain 4 (flag epitope) to which a MoAb has been previously developed. As a negative control, we used the anti-βc MoAb 1C1 which recognizes an epitope located elsewhere in βc. Figure 2C shows that BION-1 immunoprecipitated a band of about 80,000 MW from ^{125}I-surface labelled-domain 4-expressing CHO cells consistent with the expected size of domain 4. MoAb M2 against the flag epitope added to domain 4 of βc also precipitated a similar size protein. In contrast, MoAb 1C1 failed to immunoprecipitate domain 4. These

experiments show that BION-1 can specifically recognize domain 4 of βc on the surface of cells and following denaturation of the protein.

BION-1 inhibits the high affinity binding of IL-5, GM-CSF and IL-3 to TF-1 cells and to human eosinophils

Given that domain 4 of βc is crucial for the high affinity binding of IL-5, GM-CSF and IL3, we examined whether BION-1 was able to affect this binding. We found that BION-1 inhibited in a dose-dependent manner the binding of ^{125}I-IL-5, ^{125}I-GM-CSF and ^{125}I-IL-3 to the human erythroleukaemic cell line TF-1. For each radioligand we used the smallest possible concentration to maximize the possibility of measuring high affinity. This can be more readily achieved with IL-3 and GM-CSF for which the difference between the low affinity component (provided by each α chain alone) and the high affinity component (provided by co-expressing βc with each α chain) is about 1,000 fold and 30 fold respectively. In the case of IL-5, the affinity conversion of βc is only in the 25 fold range, hence, high and low affinity binding cannot be clearly separated. This is likely to explain why BION-1 shows complete inhibition of ^{125}I-GM-CSF and ^{125}I-IL-3 binding (Figure 3). The residual ^{125}I-IL-5 binding seen with high concentrations of BION-1 is likely to be the result of low affinity ^{125}I-IL-5, binding (α chain) which BION-1 would not be expected to inhibit. This is consistent with BION-1 inhibition of ^{125}I-IL-5, binding reaching a plateau beyond which no further inhibition can be detected (Fig 3a). Other anti-βc MoAb (anti-,βc control) and the IgG_1 MoAb control did not inhibit ^{125}I-IL-5, ^{125}I-GM-CSF and ^{125}I-IL-3 binding to TF-1 cells (Figure 3).

The blocking effect of BION-1 was seen whether the MoAb was used as purified IgG or as Fab' fragment. Figure 4 shows that the Fab' fragment of BION-1 blocked the binding of 50 pM ^{125}I-IL-5, 50 pM ^{125}I-GM-CSF and 200 pM ^{125}I-IL-3 to TF-1 cells.

Since one of the major clinical utilities of blocking IL-5, GM-CSF and IL-3 binding is likely to be in asthma, a disease in which eosinophils are believed to play a major role, it was important to test whether BION-1 could block the binding of IL-5, GM-CSF and IL-3 to these cells. As shown in Figure 5, BION-1 inhibited the binding of all three radio-labelled cytokines to purified human

eosinophils. In contrast, other anti-βc MoAb or the IgG_1 MoAb control failed to do so.

Epitope mapping of BION-1

The fact that BION-1 inhibited the binding of ^{125}I-IL-5, ^{125}I-GM-CSF and ^{125}I-IL-3 to TF-1 cells and eosinophils suggested that it might be binding to the critical region in βc to which these cytokines bind or at least in close proximity to it. To try to define the region/epitope in βc recognized by BION-1, we used several mutants of βc and examined whether substitutions of individual amino acids in the predicted B'-C' loop or F'-G' loop impaired BION-1 binding. Two sets of experiments were carried out. In the first instance we immunoprecipitated wild type βc from transfected COS cells with a MoAb anti-βc. The immunoprecipitates were then tested for reactivity with the control anti-βc MoAb 1C1, or BION-1. The results shows that βc mutants carrying the substitutions M363A/R364A, or E366A or R418A were not recognized by BION-1 (Figure 6). In a second set of experiments, the direct binding of radio-labelled BION-1 was measured on transfectants expressing the same mutants. Similar results were obtained in that whilst 1C1 bound with similar affinity to wild type βc and the βc mutants, BION-1 binding was eliminated by the M363A/R364A, E366A and R418A mutants (Table I). These results suggest that the epitope recognized by BION-1 is formed, at least in part, by M363 and/or R364, E366 and R418. This is consistent with the disclosure in WO 97/28190 that agents that bind the putative F'-G' loop (of which R418 is part of) will be antagonists of IL-5, GM-CSF and IL-3.

BION-1 and IL-3 reciprocally inhibit each other's binding

To confirm that the epitope recognized by BION-1 was the same or close to the binding site utilized by IL-5, GM-CSF and IL-3, we performed the reverse experiment, in which BION-1 was radio-labelled and increasing concentrations of IL-3 used to compete for ^{125}I-BION-1 binding. The results showed (Figure 7) that IL-3 competed for ^{125}I-BION-1 binding in a dose-dependent manner emphasizing the close and intimate proximity of BION-1 and IL-3 binding epitopes in βc

BION-1 specifically inhibits the function of IL-5, GM-CSF and IL-3 including their stimulation of eosinophil production and activation.

To ascertain whether the inhibition of IL-5, GM-CSF and IL-3 binding by BION-1 was translated into inhibition of IL-5, GM-CSF and IL-3 stimulation we used the factor dependent TF-1 cell line. This cell line proliferates in the presence

of either IL-5, GM-CSF, IL-3 or erythropoietin (EPO) (Figure 8). As shown in Figure 8 MoAb BION-1 but not other MoAb anti-βc nor an IgG_1 control MoAb inhibited the stimulation of TF-1 cell proliferation by IL-5, GM-CSF and IL-3. In contrast, the stimulating ability of erythropoietin was not inhibited showing specificity of BION-1 for the IL-5/GM- CSF/IL-3 receptors system.

Titration experiments showed that BION-1 inhibited cytokine-mediated TF-1 cell proliferation in a dose-dependent manner with an ED_{50} of about 100-300 nM (Figure 9). Figure 9 also shows that other anti-βc MoAb were not inhibitory, and that Fab fragments of BION-1 behaved similarly to BION-1 as a whole IgG with virtually overlapping ED_{50} values.

Since eosinophils are believed to be the major effector cells in asthma and they respond to IL-5, GM-CSF and IL-3, we examined BION-1 for its ability to block eosinophil production, eosinophil survival and eosinophil activation in response to these three cytokines. We found that BION-1 but not MoAb 8E4 inhibited the ability of IL-5, GM-CSF and IL-3 to stimulate the formation of eosinophil colonies from human bone marrow cells (Table II).

Importantly, BION-1 inhibited the pro survival activity of IL-5, IL-3 and GM-CSF on purified peripheral blood human eosinophils. Whilst these cytokines are essential for maintaining eosinophil viability (Figure 10A), blocking of βc by MoAb BION-1 promotes eosinophil cell death to levels similar to those observed in the absence of cytokines (Figure 10B). Eosinophils can be activated by IL-5, GM-CSF and IL-3 as well as by tumour necrosis factor (TNF-α), a factor that operates through the TNF-α receptor. A sign of eosinophil activation is the upregulation of the CD69 surface antigen, a phenomenon induced by all four cytokines (Figure 11A). Using this activation system we found that BION-1 inhibited the activation of eosinophils by IL-5, GM-CSF and IL-3 (Figure 11B). Other MoAb anti-βc or IgG_1controls failed to do so. In addition the blocking effect of BION-1 was found to be specific in that the stimulating activity of TNF-α was not inhibited (Figure 11B).

<u>BION-1 specifically inhibits IL-3 receptor dimerization and activation</u>

In order to define the mechanism of BION-1 antagonism we examined BION-1 for its ability to influence receptor dimerization and activation. We have previously shown that IL-3 or GM-CSF or IL-5 induce dimerization of the respective α

chains with β_c, a phenomenon that leads to receptor activation as measured by tyrosine phosphorylation of β_c. This is confirmed here, with Figure 12 showing that in the absence of cytokines antibodies to the α chain (left panel), or β_c (right panel), immunoprecipitate their appropriate antigens (α chain and β_c respectively). In the presence of IL-3, dimerization of α and β_c takes place allowing either anti-α chain or anti β_c MoAb to immunoprecipitate both receptor subunits. This is accompanied by tyrosine phosphorylation of β_c (top panel). We show in this figure that pre-incubation of the cells with BION-1 blocks receptor dimerization and tyrosine phosphorylation of β_c. As a control we used the anti β_c MoAb 1C1 which was unable to prevent receptor dimerization and activation.

BION-1 specifically inhibits chronic myelomonocytic cell growth

BION-1 is shown to inhibit the activity of one or all of IL-5, IL-3 & GM-CSF mediated effectors of leukaemic cells. In particualr BION-1 inhibits growth *in vitro* of chronic myelomonocytic cells (CMML), whereas a control antibody (1C1) does not (Figure 14). Furthermore, BION-1 inhbits even in the presence of IL-3 whereas the control does not.

Screening and isolation of new inhibitory compounds

A large range of potential therapeutic compounds that might act as antagonists, or perhaps agonists of IL-3, GM-CSF and IL-5 individually or collectively, can be readily screened. The screening is initially to determine whether the binding of BION-1 or a fragment thereof to β_c receptor or fragment is inhibited. The nature of these inhibitory compounds will not be limited, and the methods used for a binding assay can be any one of the many techniques known to those skilled in the art. Such methods may include affinity selection chromatography, ultrafiltration assays, the scintillation proximity assay, interfacial optical techniques, the quartz crystal microbalance, the jet ring cell, interferometric assays using porous silicon to immobilise the receptor. Reference to such techniques can be found in Woodbury *et al* 1999, which reference is incorporated herein in its entirety.

The range of therapeutic compounds may include peptides, oligonucleotides, or other small organic or inorganic molecules. Figure 13 shows the results of screening 7-mer and 12-mer peptide libraries using soluble β_c domain 4 supported on ELISA plates.

DEPOSIT OF CELL LINE

The cell line BION-1 was deposited on the April 29th, 1998 in the American Type Culture Collection (ATCC) at 101801 University Boulevard, Manassas, Virginia, United States of America and has been designated ATCC HB-12525.

Table I Epitope mapping of Bion-1. Binding affinities of MoAb Bion-1 tested on COS cells transfected with wild type β_c or mutants of β_c

β_c wild type:	Bion-1 KD	1C1 KD
	49.3*	4.4
β_c mutated in the B'-C' loop:		
M363A/R364A	0 †3.8	
Y365A	69.41.5	
E366A	02.4	
H367A	27.02.8	
1368A	21.72.4	
D369A/H370A	32.43.6	
β_c mutated in the F'-G' loop:		
R418A	0	1.8
T419A	23.3	3.2
G420A	53.0	1.5
Y421A	38.9	2.3

* K_D in nM

0† = not detectable binding

Table II Inhibition of IL-5, GM-CSF and IL-3 mediated eosinophil colony formation by BION-1

	Medium	[MoAb 8E4] (100 µM)		[MoAb BION-1] (µM)		
			0.1	1	10	100
IL-5 (lnM)	13 ± 4*	15 ± 3	13 ± 4	8 ± 2	2 ± 2	2 ± 0
GM-CSF (2nM)	9 ± 4	18 ± 4	20 ± 4	13 ±4	2 ± 2	0 ± 0
IL-3(2nM)	4 ± 2	8 ± 1	8 ± 2	4 ± 1	1 ± 1	0 ± 1
NONE	0 ± 0	0 ± 0	0 ± 0	0 ± 0	2 ± 0	0 ± 0

*Number of day 14 eosinophil colonies per 10^5 seeded bone marrow cells. Values shown are the mean from triplicate determination ± SEM.

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Vadas *et al* (1979)*J Immunol* **122**, 1228-1236

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Woodbury, C.P. et al (1999) *J Chromatogr B Biomed Sci Appl* **725(1)**:113-37.

Woodcock *et al* (1994) *EMBO J***13**:5176

Woodcock *et al,* (1996) *J Biol Chem* **271**, 25999-26006

Zurawski,S.M. *et al* (1993) *EMBO J.*, **12**, 2663-2670.

INDICATIONS RELATING TO DEPOSITED MICROORGANISM OR OTHER BIOLOGICAL MATERIAL

(PCT Rule 13*bis*)

A. The indications made below relate to the deposited microorganism or other biological material referred to in the description on page 23, line 1-4.

B. IDENTIFICATION OF DEPOSIT — Further deposits are identified on an additional sheet ☐

Name of depositary institution

American Type Culture Collection

Address of depositary institution *(including postal code and country)*

10801 University Blvd
Manassas, VA 20110-2209
United States of America

Date of deposit	Accession Number
29 April 1998	HB-12525

C. ADDITIONAL INDICATIONS *(leave blank if not applicable)* — This information is continued on an additional sheet ☐

D. DESIGNATED STATES FOR WHICH INDICATIONS ARE MADE *(if the indications are not for all designated States)*

E. SEPARATE FURNISHING OF INDICATIONS *(leave blank if not applicable)*

The indications listed below will be submitted to the International Bureau later *(specify the general nature of the indications e.g., "Accession Number of Deposit")*

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Authorized officer (Mrs) Anne HAMMETT (02) 6283 2225	Authorized officer

CLAIMS

1. A method of isolating a monoclonal antibody capable of inhibiting any one of IL-3, GM-CSF and IL-5 binding to the common receptor β_c, or a receptor analogous to β_c, said method including the steps of:

immunising an animal with a cytokine receptor or portion of a cytokine containing at least the extracellular domain 4 or analogous domain in the analogous common receptor or part thereof,

isolating antibody producing cells from said animal,

fusing antibody producing cells with a myeloma cell line, and

screening for a cell line that produces the monoclonal antibody of capable of inhibiting any one of IL-3, GM-CSF and IL-5 binding to the common receptor β_c, or a receptor analogous to β_c.

2. A method as in claim 1 wherein the immunisation involves introducing a cDNA clone of a portion of or all of the common receptor including the extracellular domain 4 or analogous domain in the analogous common receptor or part thereof, into a cell and proliferating said cells to form a recombinant cell line, inoculating an animal with said recombinant cell line, isolating antibody producing cells from said animal and fusing the antibody producing cell line with a myeloma cell line to form a hybridoma cell line, screening for a hybridoma cell line that produces an antibody that binds to the recombinant cell line but not to the parent, and then testing for inhibition against all three cytokines.

3. A method as in claim 2 wherein the cell into which the cDNA clone is introduced is mammalian.

4. A method as in claim 3 wherein the mammalian cell line is a COS cell.

5. A method as in claim 2 wherein the cDNA encodes a full or partial portion of domain 4 when it is in a configuration where the F'-G' loop and/or the B'-C' loop is in its native shape.

6. A method as in claim 2 wherein the domain 4 of β_c or equivalent domain in other cytokine receptors is expressed in isolation in a microbial host and used to immunise animals for developing monoclonal antibodies.

7. A method as in claim 2 wherein the analogous receptor is any one of the cytokine superfamily receptors from the group including β_c, LIFR, gp130, IL-2Rβ, IL-4R/IL-13R, IL-2Rγ, IL-3Rα, EPOR, TPOR and OBR.

8. A method as in claim 2 wherein the method is used to isolate a monoclonal antibody that inhibits binding of all of the said receptors to a common receptor.

9. A method as in claim 7 wherein the common receptor is selected from the group of receptors acting for more than one cytokine including but not limited to gp130, LIFR, IL2Rβ/IL2Rα, IL-4R/IL-13R and β_c.

10. A monoclonal antibody, or fragments thereof capable of inhibiting the binding of the cytokines IL-3, GM-CSF and IL-5 to the β_c receptor.

11. A monoclonal antibody as in claim 10 wherein the monoclonal antibody or fragment thereof binds to at least the F'-G' loop of domain 4 of the β_c subunit.

12. A monoclonal antibody as in claim 10 wherein the monoclonal antibody or fragment thereof binds to at least the B'-C' loop of domain 4 of the β_c subunit.

13. A monoclonal antibody as in claim 10 wherein the monoclonal antibody or fragments thereof binds to both the F'-G' as well as the B'C' loop of domain 4 of the β_c.

14. A monoclonal antibody as in claim 10 wherein the monoclonal antibody inhibits β_c receptor dimerisation.

15. A monoclonal antibody as in claim 10 wherein nucleic acid encoding the variable region of the monoclonal antibody is recombined with nucleic acid encoding non-variable regions of human origin in an expression vector.

16. A monoclonal antibody as in claim 10 wherein the inhibition leads to blocking of at least one function of all three cytokines.

17. A monoclonal antibody as in claim 10 wherein the activity leads to inhibition of stimulation of effector cell activation or survival.

18. A monoclonal antibody as in claim 17 wherein the antibody or fragment thereof is used for treatment of asthma and leads to inhibition of IL-5, IL-3 & GM-CSF mediated eosinophil activation.

19. A monoclonal antibody as in claim 17 wherein the antibody or fragment thereof is used for treatment of asthma and leads to inhibition of IL-5, IL-3 & GM-CSF mediated eosinophil survival.

20. A monoclonal antibody as in claim 17 wherein the effector cell is selected from the list including leukaemic cells, endothelial cells, breast cancer cells, prostate cancer cells, small cell lung carcinoma cells, colon cancer cells, macrophages in chronic inflammation, and dendritic cells for immunosuppression.

21. A monoclonal antibody as in claim 17 wherein the monoclonal antibody is the antibody produced by the hybridoma cell line BION-1 (ATCC HB-12525).

22. A hybridoma cell line capable of producing the monoclonal antibody of claim 10.

23. A hybridoma cell line as in claim 22 wherein the hybridoma cell line is BION-1 (ATCC HB-12525).

24. A method of isolating an inhibitor capable of competitively inhibiting the binding of BION-1 or the binding of an agent capable of inhibiting BION-1 binding, to the β_c subunit, the method including the steps of contacting BION-1 or fragment thereof with the β_c subunit or fragment thereof as well as a candidate inhibitory compound,

and measuring the degree of binding.

25. A method as in claim 24 wherein a reporting means is provided to facilitate the detection of binding of BION1 or fragment thereof with β_c subunit or fragment thereof.

26. A method as in claim 24 wherein the inhibitor is a peptide or a nucleotide molecule.

27. An inhibitor isolated by the method of claim 24.

28. A cytokine inhibitor that simultaneously blocks the binding of β_c by IL-3, GM-CSF, and IL-5.

29. An inhibitor of leukaemic cell proliferation wherein the inhibitor inhibits binding of IL-3, GM-CSF and IL-5 with β_c subunit or fragment thereof.

30. An inhibitor as in claim 29 wherein the proliferation of the cell is cytokine dependent.

31. An inhibitor as in claim 29 wherein the inhibitor is BION-1 or an agent capable of inhibiting BION-1 binding with β_c subunit or fragment thereof.

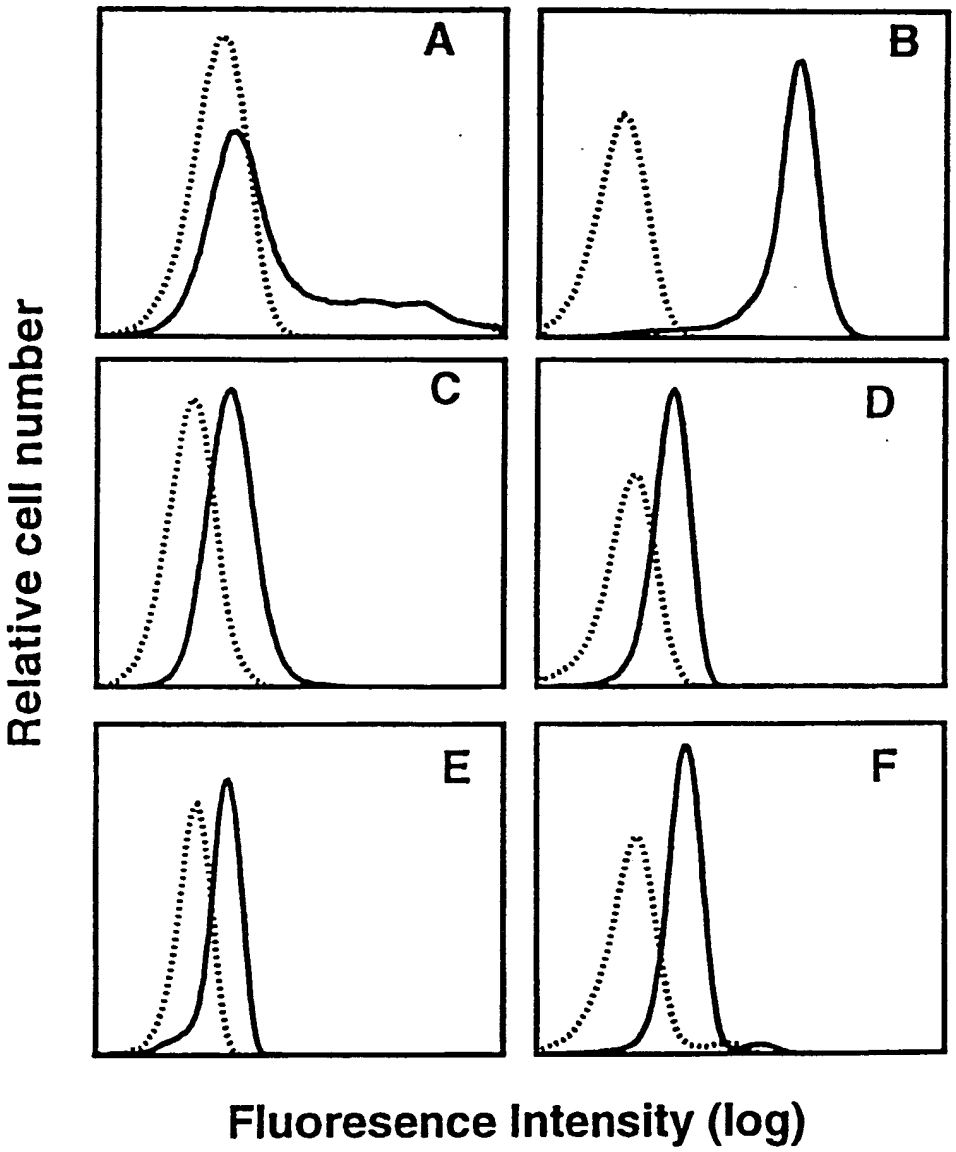


FIGURE 1

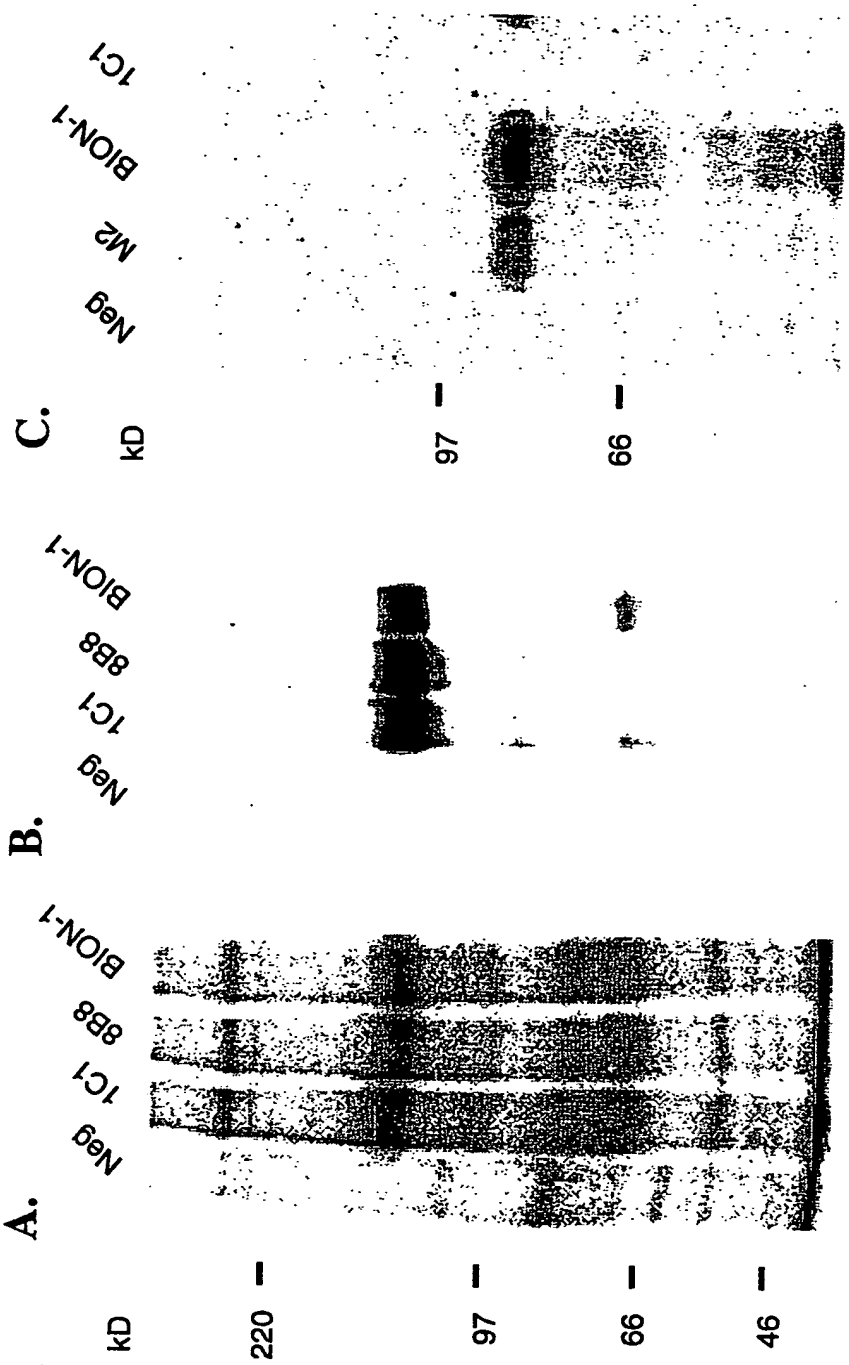

C.
kD
97
66
Neg
M2
BION-1
1C1
B.
Neg
1C1
BB8
BION-1
A.
Neg
1C1
BB8
BION-1
kD
220
97
66
46

FIGURE 2

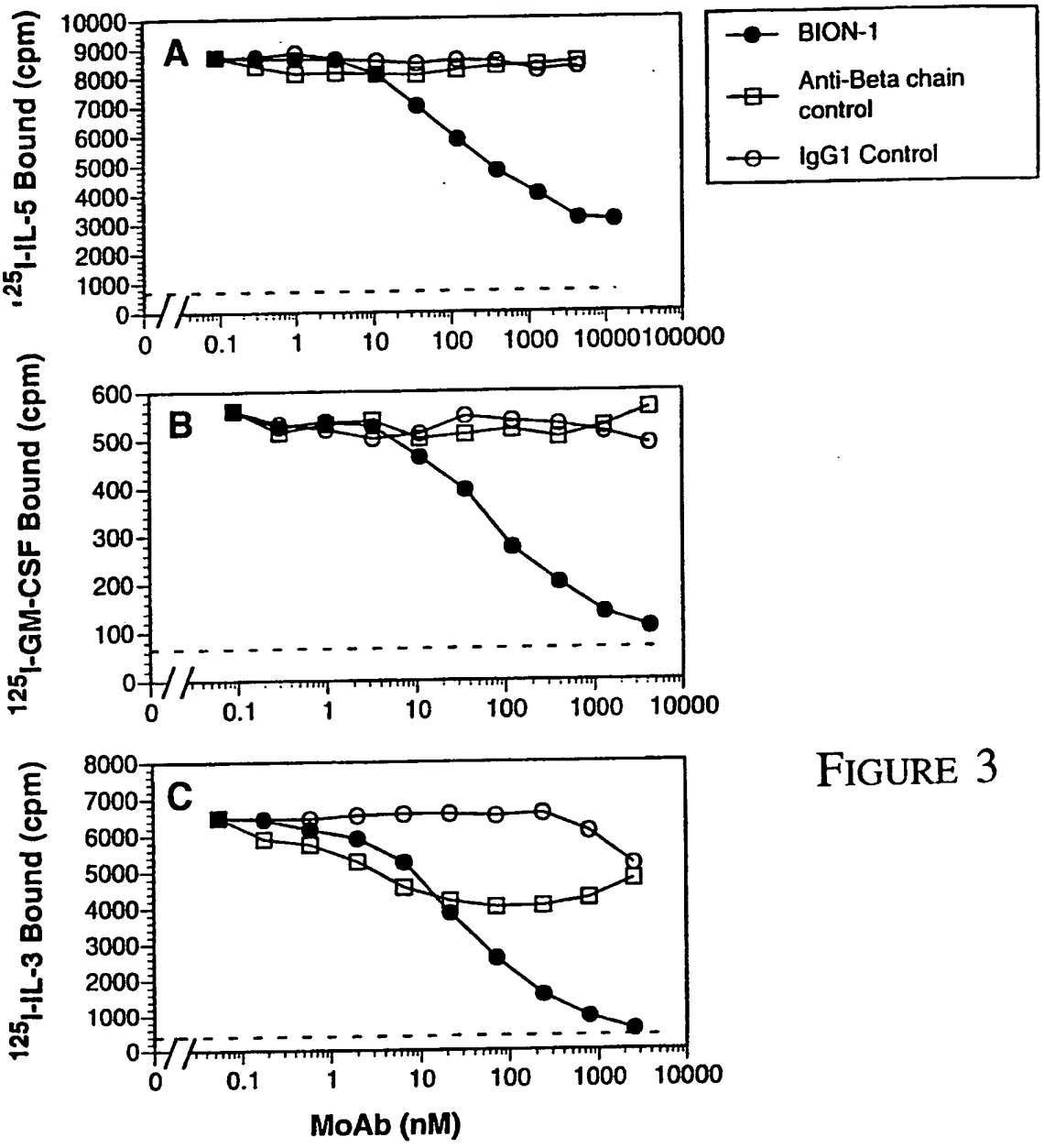

A
B
C
BION-1
Anti-Beta chain control
IgG1 Control
^{125}I-IL-5 Bound (cpm)
^{125}I-GM-CSF Bound (cpm)
^{125}I-IL-3 Bound (cpm)
MoAb (nM)
0
0.1
1
10
100
1000
10000
100000

FIGURE 3

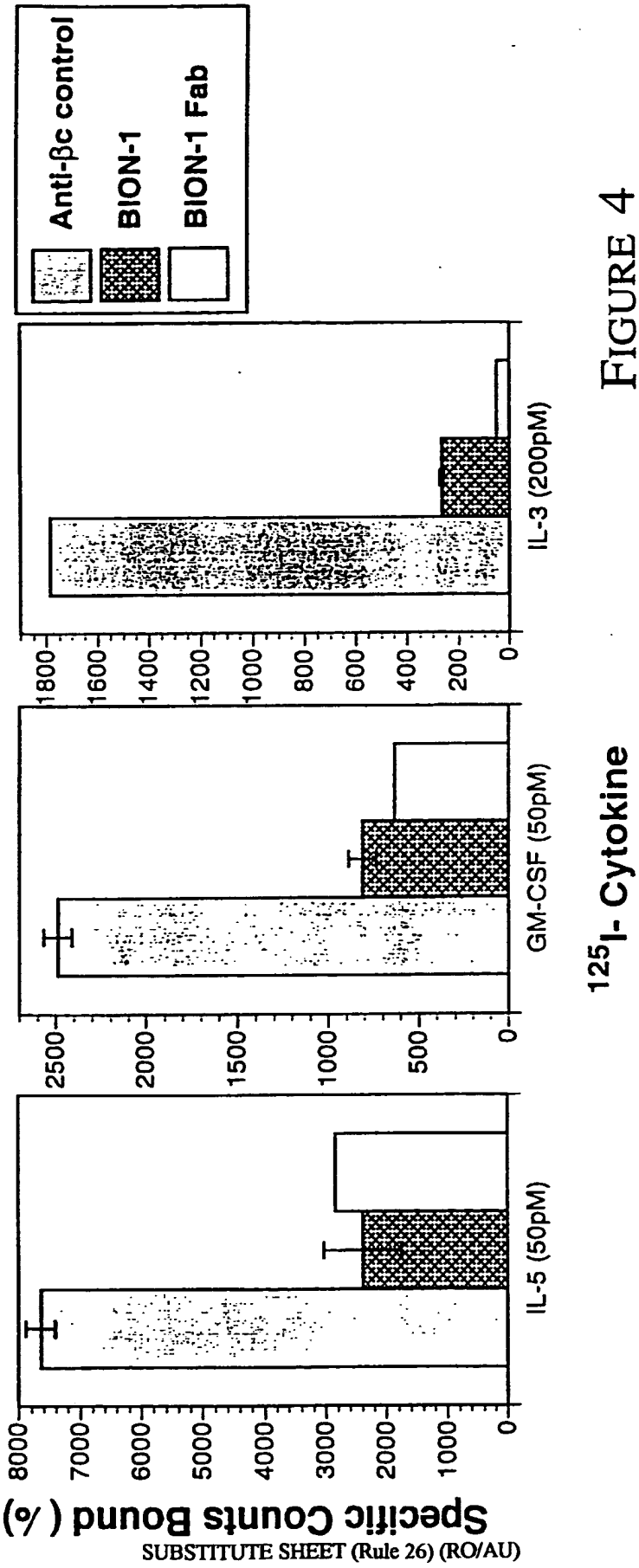

Anti-βc control
BION-1
BION-1 Fab
Specific Counts Bound (%)
125I- Cytokine
IL-5 (50pM)
GM-CSF (50pM)
IL-3 (200pM)
0
1000
2000
3000
4000
5000
6000
7000
8000
500
1000
1500
2000
2500
200
400
600
800
1000
1200
1400
1600
1800

FIGURE 4

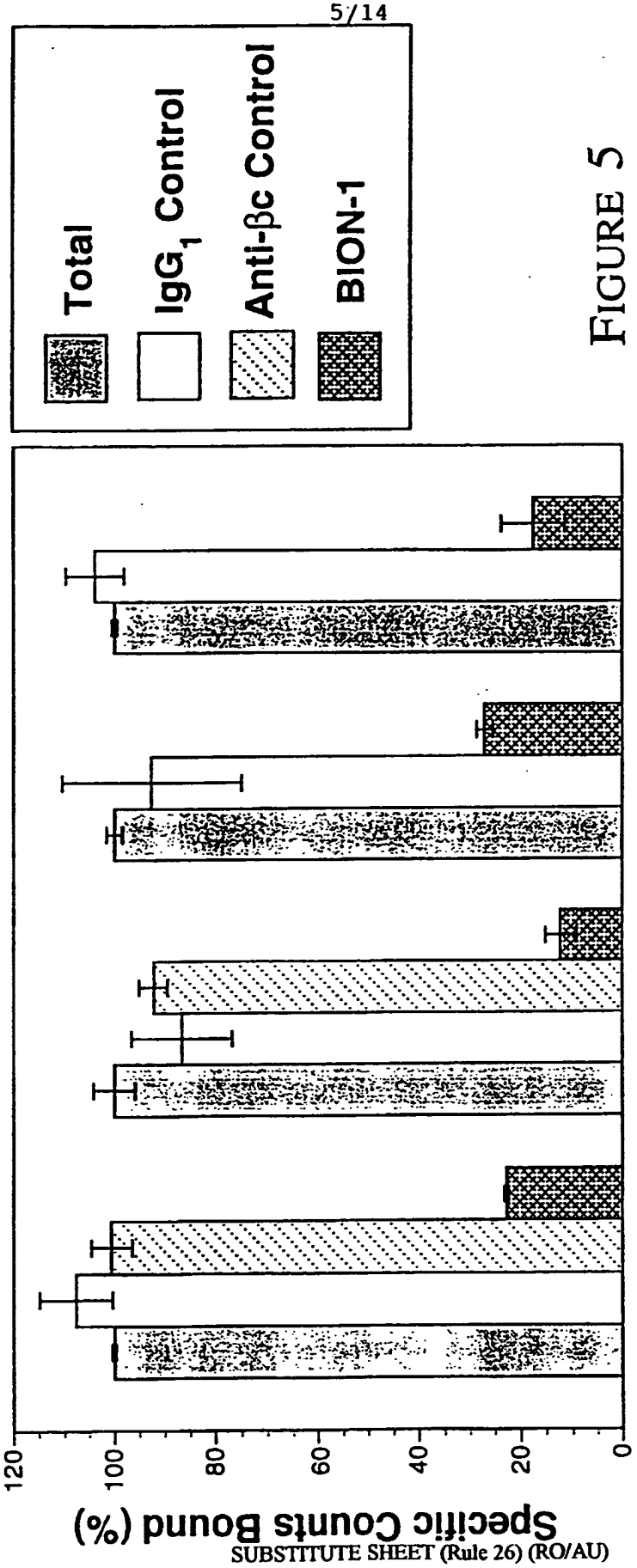

Total
IgG1 Control
Anti-βc Control
BION-1
Specific Counts Bound (%)
120
100
80
60
40
20
0
IL-5 (10pM)
IL-5 (3pM)
GM-CSF (50pM)
IL-3 (200pM)
125I-Cytokines

FIGURE 5

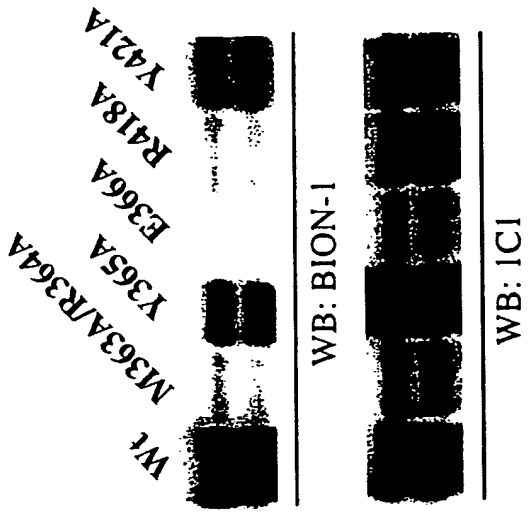


FIGURE 6

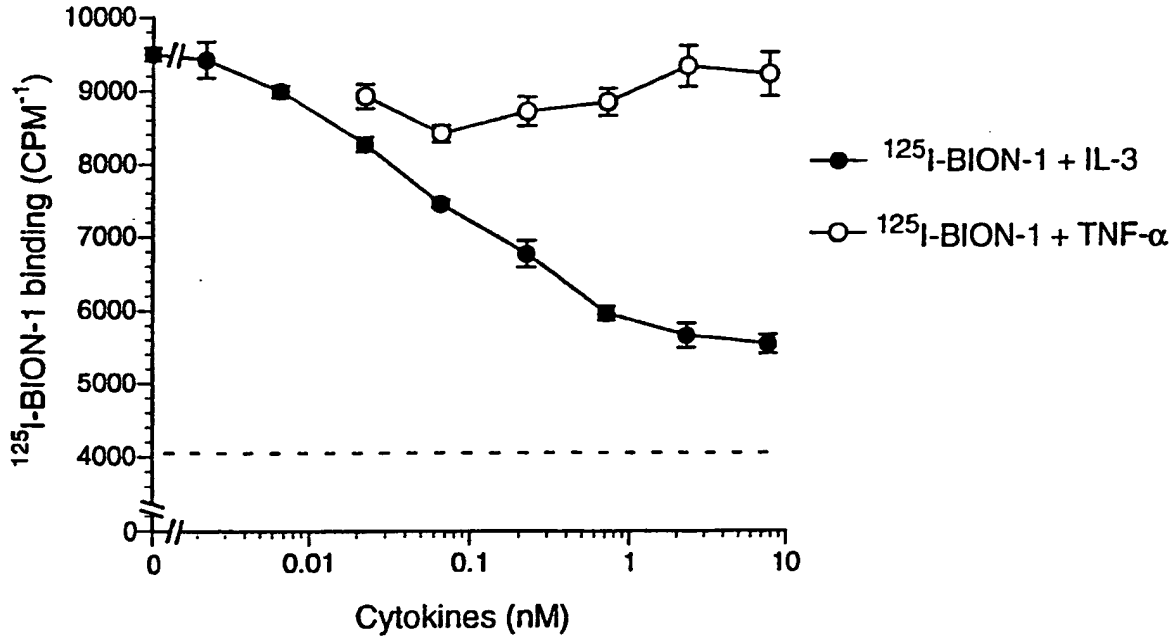

10000
9000
8000
7000
6000
5000
4000
0
^{125}I-BION-1 binding (CPM^{-1})
0
0.01
0.1
1
10
Cytokines (nM)
^{125}I-BION-1 + IL-3
^{125}I-BION-1 + TNF-α

FIGURE 7

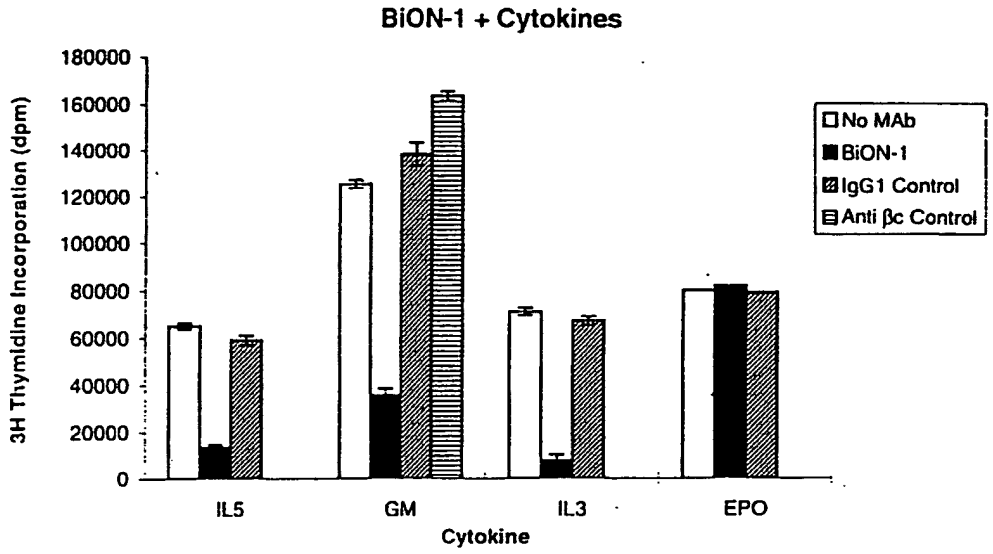
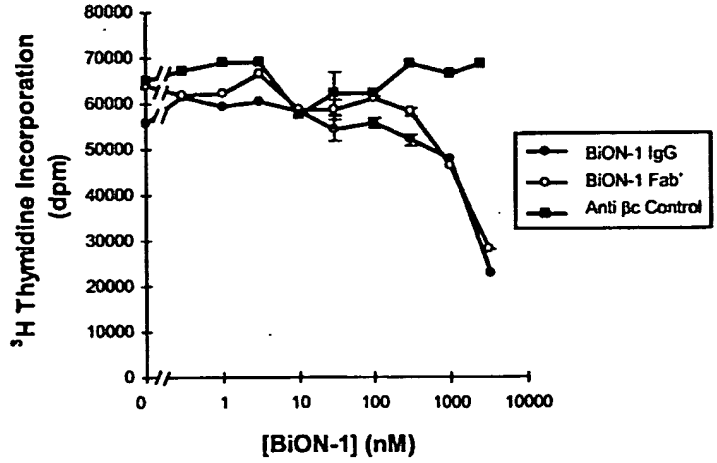

BiON-1 + Cytokines
3H Thymidine Incorporation (dpm)
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
IL5
GM
IL3
EPO
Cytokine
No MAb
BiON-1
IgG1 Control
Anti βc Control

FIGURE 8

BiON-1 + IL5 (0.3ng/ml)



BiON-1 + GM-CSF (0.03ng/ml)

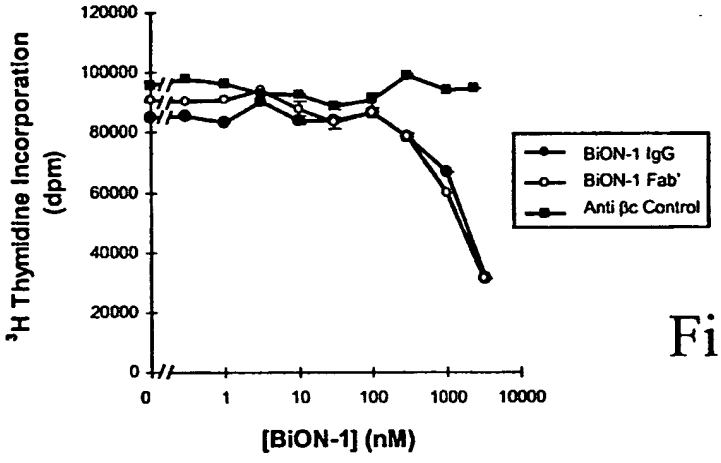
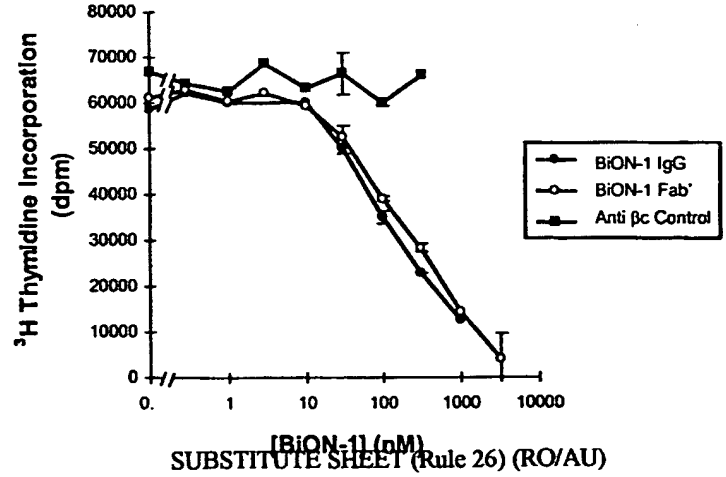
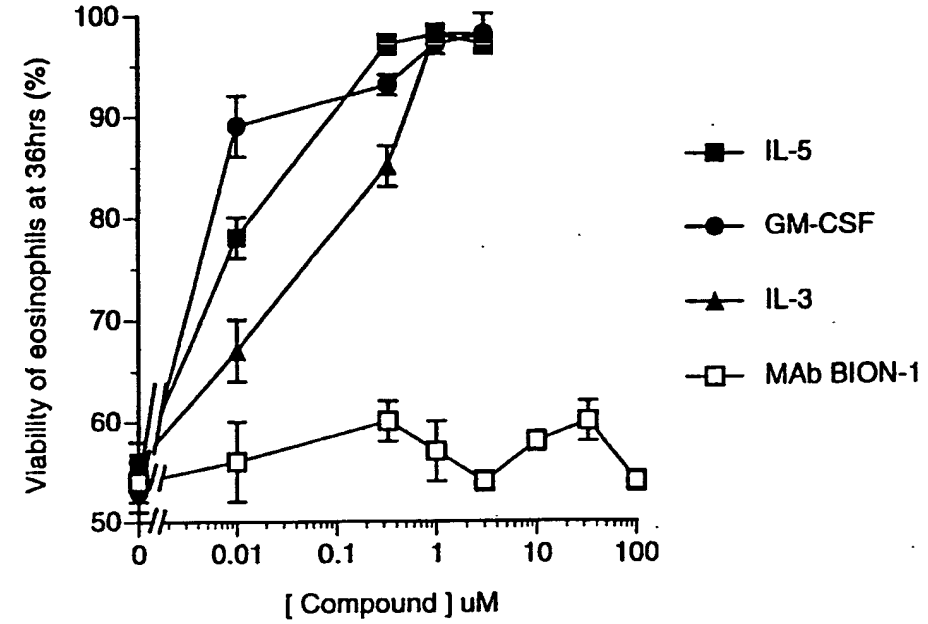


Figure 9

BiON-1 + IL3 (0.3ng/ml)



A)


Viability of eosinophils at 36hrs (%)
100
90
80
70
60
50
0
0.01
0.1
1
10
100
[Compound] uM
IL-5
GM-CSF
IL-3
MAb BION-1

B)

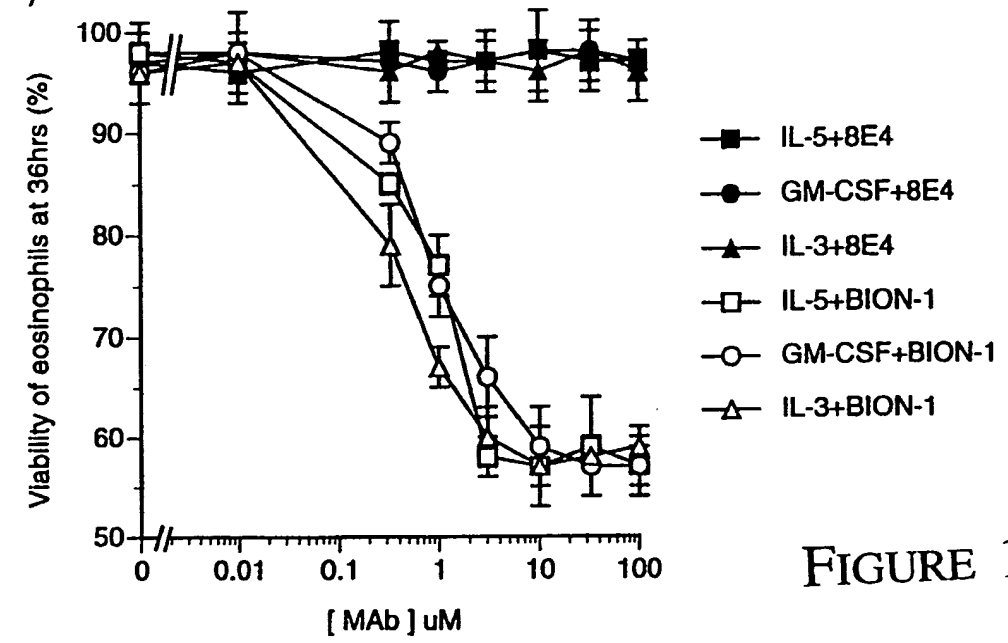

Viability of eosinophils at 36hrs (%)
100
90
80
70
60
50
0
0.01
0.1
1
10
100
[MAb] uM
IL-5+8E4
GM-CSF+8E4
IL-3+8E4
IL-5+BION-1
GM-CSF+BION-1
IL-3+BION-1

FIGURE 10

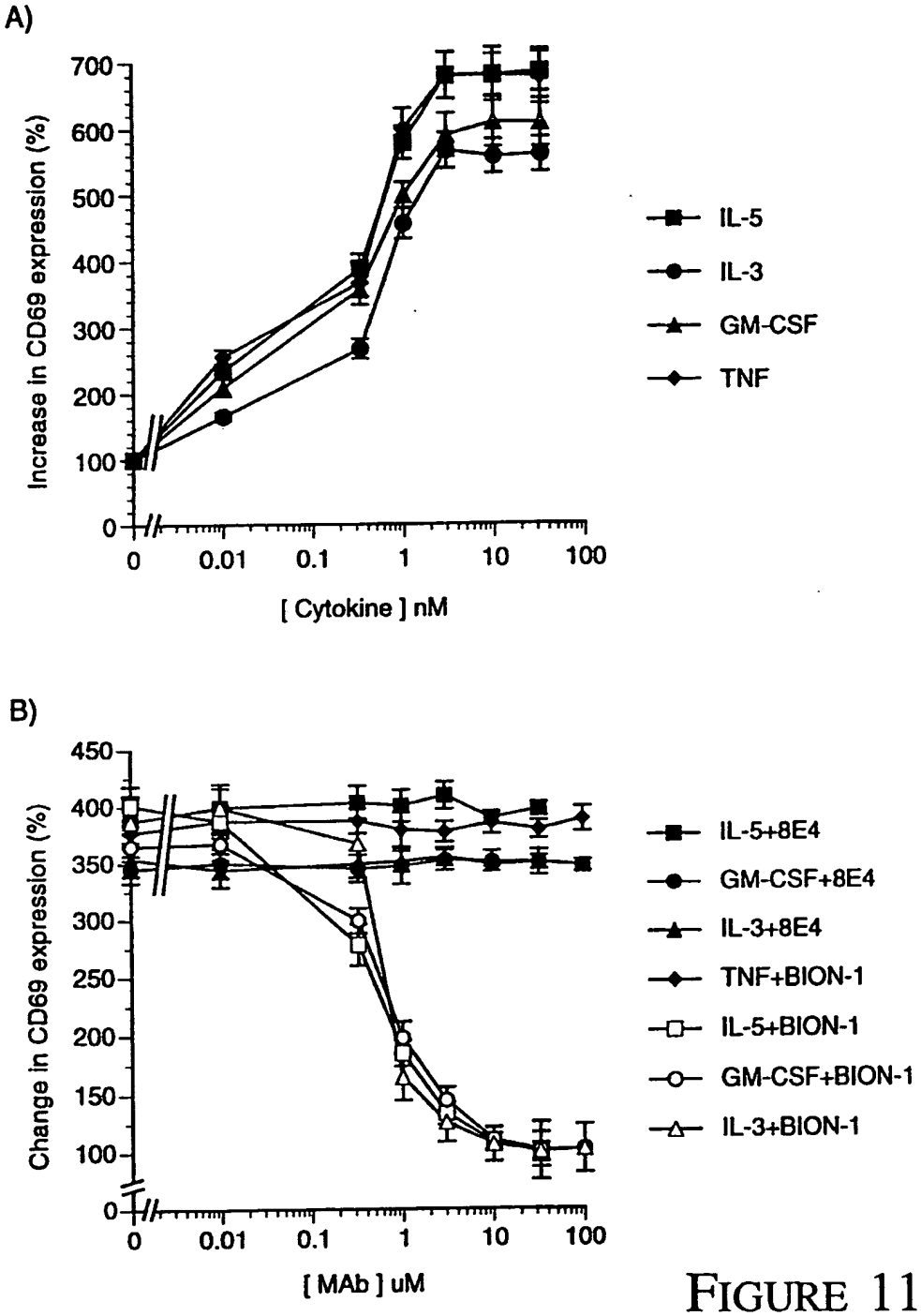

A)
Increase in CD69 expression (%)
700
600
500
400
300
200
100
0
0
0.01
0.1
1
10
100
[Cytokine] nM
IL-5
IL-3
GM-CSF
TNF
B)
Change in CD69 expression (%)
450
400
350
300
250
200
150
100
0
0
0.01
0.1
1
10
100
[MAb] uM
IL-5+8E4
GM-CSF+8E4
IL-3+8E4
TNF+BION-1
IL-5+BION-1
GM-CSF+BION-1
IL-3+BION-1

FIGURE 11

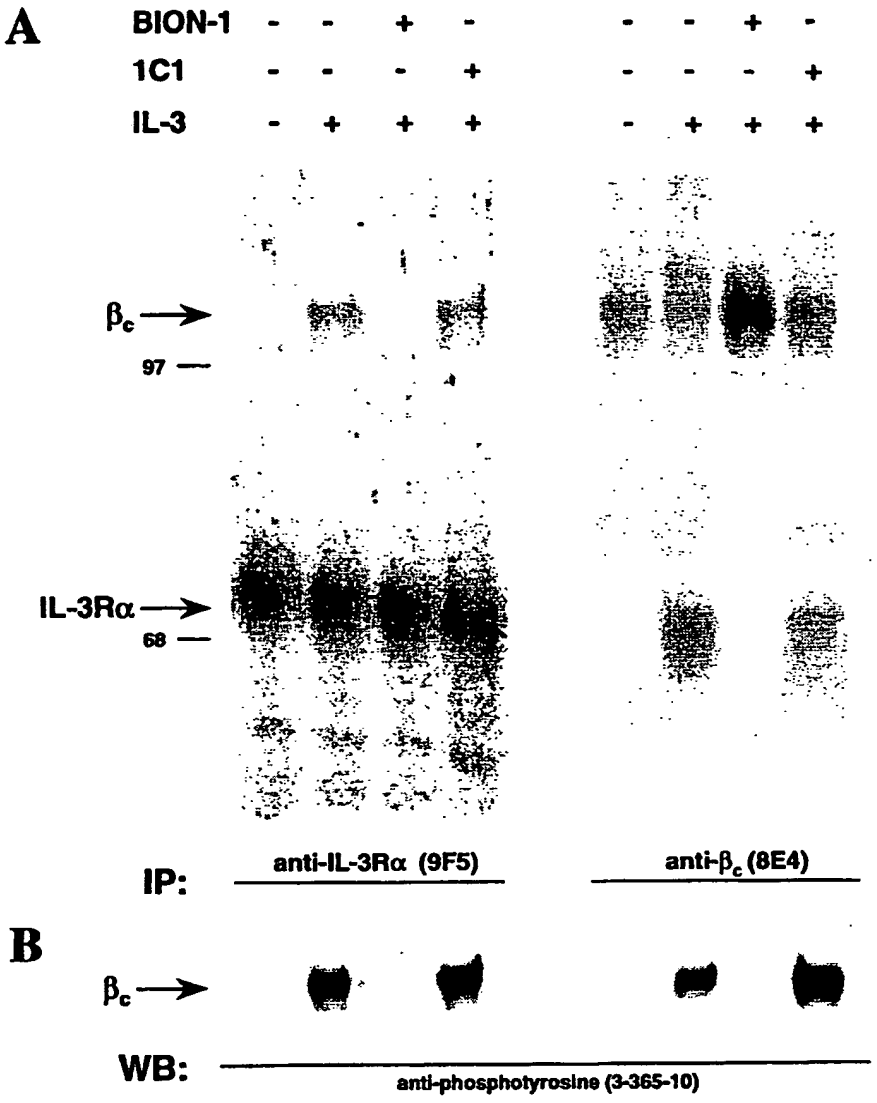

A
BION-1 - - + - - - + -
1C1 - - - + - - - +
IL-3 - + + + - + + +
βc
97
IL-3Rα
68
IP:
anti-IL-3Rα (9F5)
anti-βc (8E4)
B
βc
WB:
anti-phosphotyrosine (3-365-10)

FIGURE 12

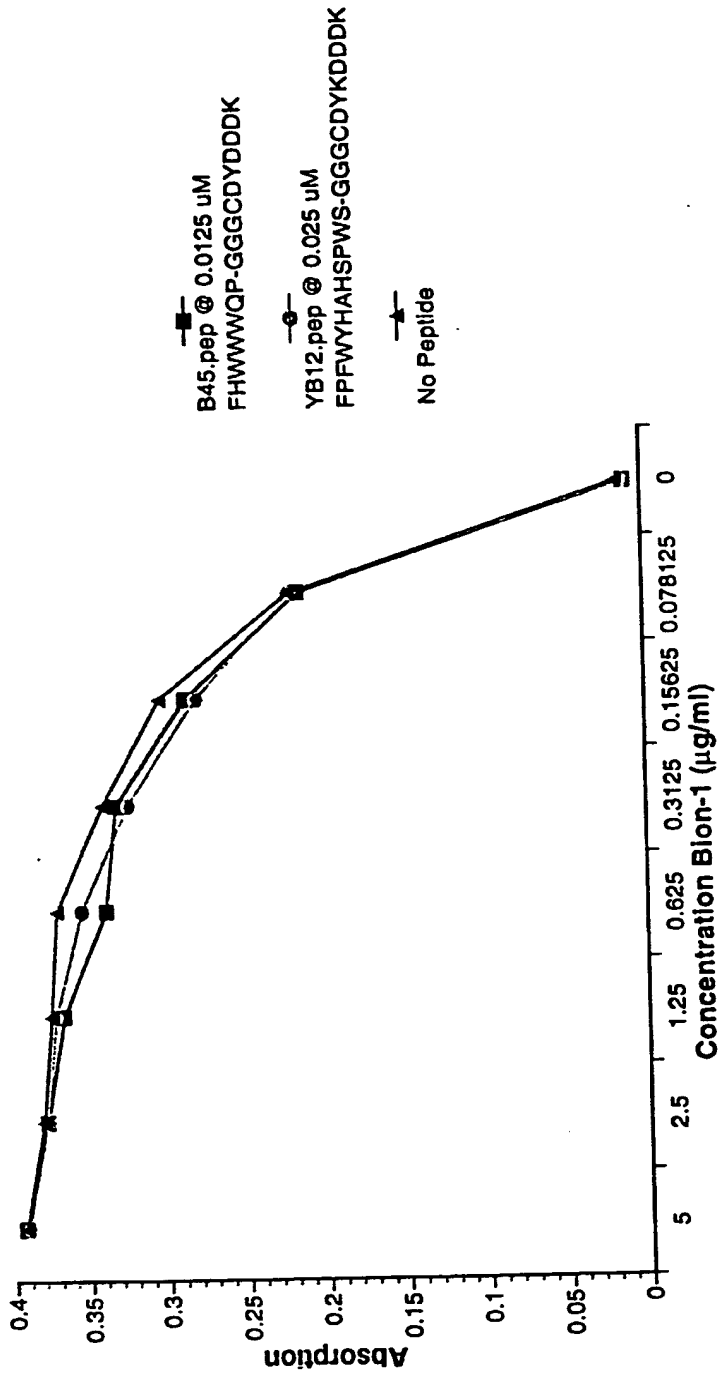

B45.pep @ 0.0125 uM
FHWWWQP-GGGCDYDDDK
YB12.pep @ 0.025 uM
FPFWYHAHSPWS-GGGCDYKDDDK
No Peptide
Absorption
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5
2.5
1.25
0.625
0.3125
0.15625
0.078125
0
Concentration Bion-1 (µg/ml)

FIGURE 13

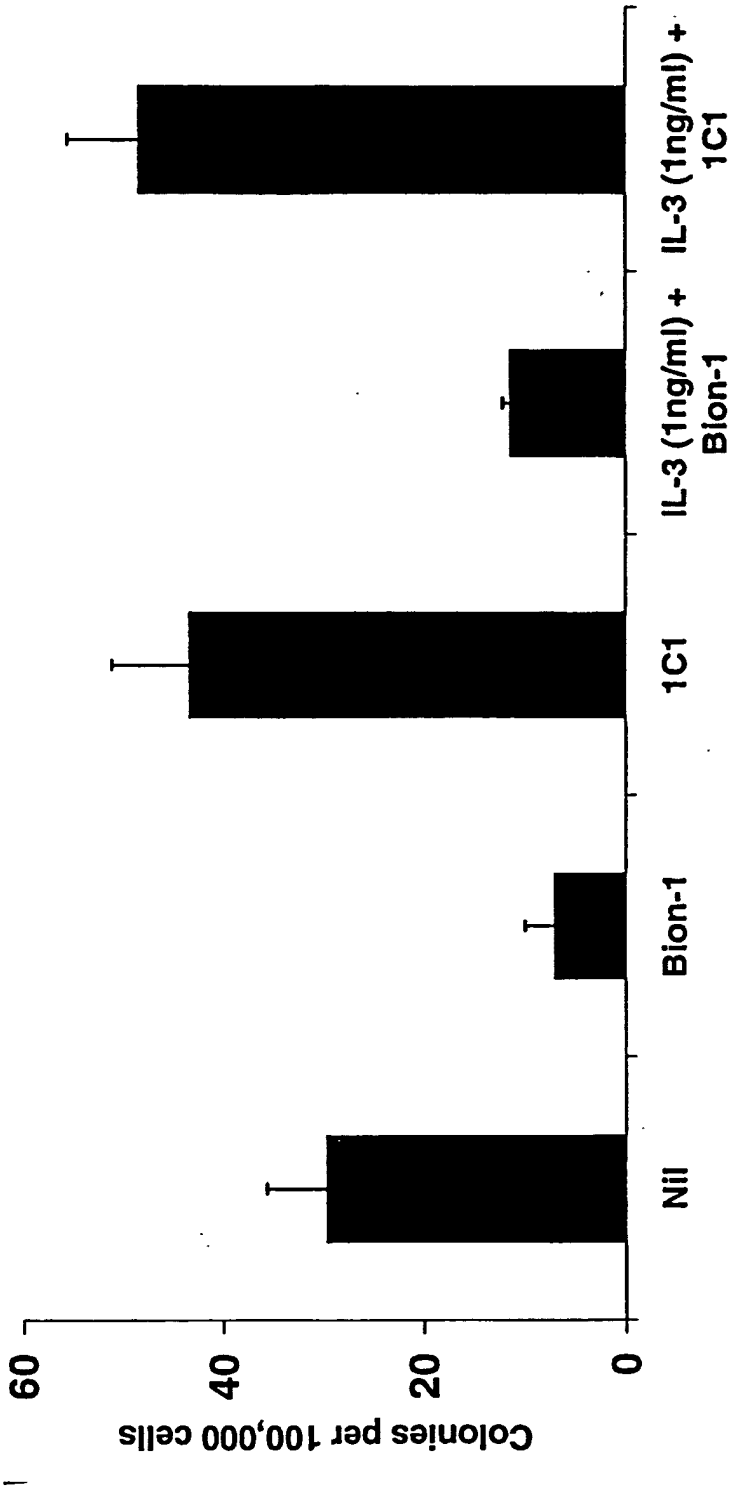

Colonies per 100,000 cells
0
20
40
60
Nil
Bion-1
1C1
IL-3 (1ng/ml) + Bion-1
IL-3 (1ng/ml) + 1C1

FIGURE 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00659

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: C07K 16/24 16/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07K 16/24 16/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MEDLINE, CA, WPIDS through STN. Keywords: Monoclonal(w)antibod, Beta C, Beta Subunit, Cytokine.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 15366/97 (706462) B (MEDVET SCIENCE PTY. LTD.) 22 August 1997 see the abstract and claim 1	1 - 31
A	BLOOD, Volume 80, No. 9, November 1 1992, (U.S.), Watanabe Y et al, "Monoclonal Antibody Against the Common Beta Subunit of the Human Interleukin-3 (IL-3), IL-5, and Granulocyte-Macrophage Colony-Stimulating Factor Receptors Shows Upregulation of Beta C by IL-1 and Tumour Necrosis Factor-Alpha", pages 2215-2220 see the abstract and results	1 - 31

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
11 October 1999

Date of mailing of the international search report
15 OCT 1999

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00659

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	MOLECULAR AND CELLULAR BIOLOGY. Volume 16. No. 6. June 1996. (U.S.). Stomski. F. C. et al. "Human Interleukin-3 (IL-3) Induces Disulfide-Linked IL-3 Receptor alpha- and beta-Chain Heterodimerization. Which Is Required for Receptor Activation but Not High-Affinity Binding". pages 3035-3046 see the abstract	1 - 31
A	BLOOD. Volume 90. No. 8. 15 October 1997. (U.S.). Woodcock. J. M. et al. "The Human Granulocyte-Macrophage Colony-Stimulating Factor (GM-SCF) Receptor Exists as a Preformed Receptor Complex That Can Be Activated By GM-SCF. Interleukin-3. or Interleukin-5". pages 3005-3017 see the abstract	1 - 31
A	IMMUNOLOGIC RESEARCH. Volume 13. Nos. 2.3: 1994. (U.S.). Von Feldt. J. M. et al. "Granulocyte-Macrophage Colony-Stimulating Factor Mimicry And Receptor Interactions". pages 96-109 see the abstract	1 - 31

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/AU 99/00659

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member		
AU 706462	AU15366/97	WO9728190	EP 889905

END OF ANNEX